

INSTALLATION RESTORATION PROGRAM

FINAL REMEDIAL INVESTIGATION REPORT

110th FIGHTER WING
MICHIGAN AIR NATIONAL GUARD
BATTLE CREEK, MICHIGAN

JUNE 1996

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FINAL
INSTALLATION RESTORATION PROGRAM
REMEDIAL INVESTIGATION REPORT

110th FIGHTER WING
MICHIGAN AIR NATIONAL GUARD
BATTLE CREEK, MICHIGAN

Submitted to:
AIR NATIONAL GUARD READINESS CENTER
ANDREWS AFB, MARYLAND

Submitted by:
HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
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Oak Ridge, Tennessee 37831

for the:
U.S. DEPARTMENT OF ENERGY

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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center of Environmental Excellence
AMSL	above mean sea level
ANG	Air National Guard
ANGRC	Air National Guard Readiness Center
AOC	areas of concern
ARAR	Applicable or Relevant and Appropriate Requirement
AST	aboveground storage tanks
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
BTOPC	Below top of casing
CDM	Camp Dresser and McKee
CLP	Contract Laboratory Program
COC	chain of custody
CV	Coefficient of Variation Test
DCA	Dichloroethane
DCB	Dichlorobenzene
DCE	Dichloroethylene
DOD	Department of Defense
DOE	Department of Energy
EA	Environmental Assessment
EARTH TECH	The Earth Technology Corporation
EPA	Environmental Protection Agency
ES	Engineering - Science
FCR	Field Change Request
FFS	Focused Feasibility Study
FG	Fighter Group
FIRM	Flood Insurance Rate Map
FR	Federal Register
FS	Feasibility Study
FTA	Fire Training Area
FW	Fighter Wing
GC	Gas Chromatograph
GSI	Groundwater-Surface Water Interface
HAZWRAP	Hazardous Waste Remedial Actions Program
HMTC	Hazardous Materials Technical Center
ID	inner diameter
IRP	Installation Restoration Program
LMES	Lockheed Martin Energy Systems, Inc.

MDNR	Michigan Department of Natural Resources
MERA	Michigan Environmental Response Act
MIANG	Michigan Air National Guard
NCP	National Contingency Plan
NREPA	Natural Resources and Environmental Protection Act
OM	Operational Memorandum
OWS	oil/water separator
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbon
PCA	Tetrachloroethene
PCE	Tetrachloroethylene
PID	Photoionization Detector
POL	petroleum, oil, lubricants
PP	Priority Pollutant
ppb	parts per billion
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
RA	Remedial Action
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SI	Site Investigation
SOW	Statement of Work
SRAP	Source Removal Action Plan
SQL	sample quantitation limit
SVOC	SemiVolatile Organic Compound
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
TRPC	Technical Records of Project Change
UCL	upper confidence level
$\mu\text{g}/\text{kg}$	micrograms per kilogram
$\mu\text{g}/\ell$	micrograms per liter
USDA	United States Department of Agriculture
UST	underground storage tank
v	groundwater velocity
VOC	Volatile Organic Compound
WP	Work Plan

EXECUTIVE SUMMARY

This report documents Remedial Investigation (RI) activities which EARTH TECH performed at the 110th Fighter Wing, Michigan Air National Guard, Battle Creek, Michigan under the U.S. Department of Defense Installation Restoration Program. The field activities described in this report were conducted between October 31, 1994, and May 17, 1995.

Background

Representative background concentrations of priority pollutant (PP) metals plus barium have been established for the surface and subsurface soils and groundwater beneath the base.

Base Geology and Hydrogeology

The base is underlain by a mantle of Pleistocene-aged glacial drift (sand, and sand and gravel with lesser amounts of clay and silt), approximately 100 ft thick overlying the Mississippian-aged Marshall Formation. Groundwater in the Battle Creek area occurs in useable quantities in both the glacial deposits and the Marshall Formation. These two aquifers are reported to be connected hydrologically. Three rounds of groundwater elevation measurements obtained from the base monitoring wells each show flow to the north/northwest, although a radial pattern, with a northeastern component of flow, is present in the north-central portion of the base. The May 1994 water table elevation map shows that the base is located hydraulically up-gradient from two abandoned landfills (CDM, June 1992) and from the seven monitoring wells (MW101 through MW107) located on the north side of the landfills. The nearest off-site domestic wells are located approximately one mile north (down-gradient) of the northern base boundary.

Site 1: Fuel Tank Farm/AOC B: Motor Pool Drainage Ditch

Site 1 consists of the former location of four 25,000-gallon aboveground storage tanks (ASTs) located near the drainage swale, northwest of the motor pool parking lot. Area of Concern (AOC) B: the Motor Pool Drainage Ditch, borders Site 1 on the east.

Analytical Results - Soils and Groundwater

The Site 1/AOC B surface soils contain semivolatile organic compounds (SVOCs), primarily carcinogenic (i.e., benzo (a) pyrene) and non-carcinogenic polycyclic aromatic hydrocarbons (PAHs), and metals, particularly arsenic and lead. There are three potential and probable origins for the presence of these compounds in the surface soils; 1) release(s) of fuel from the ASTs, 2) coal particles transported from Site 5, and/or 3) sandblasting and painting operations completed on or around the ASTs. Subsurface soils containing hydrocarbons appear to be limited to an area between former ASTs 2 and 3. Naphthalene and other PAHs are present within the subsurface soils at relatively high concentrations (maximum concentration of 10,000 µg/kg). These hydrocarbons are probably due to the release of heating oil from the former ASTs. The presence of hydrocarbons in the groundwater up-gradient from this location suggests that a separate release occurred along the length of the pre-existing north-south trending fuel line. No PAHs were detected in subsurface soils collected from locations where the old line used to be.

Groundwater beneath Site 1 is being monitored at the suspected point of release, up-gradient of the suspected point of release and down-gradient (both at the water table and approximately 15 to 20 ft below the water table) of the suspected point of release. No groundwater samples were collected beneath AOC B. Analytical data collected during this RI suggests that the tetrachloroethylene (PCE) detected in the groundwater screening samples did not originate from the hydrocarbon (heating oil) release, and that PAHs in excess of the NREPA PA 451 residential health-based criteria has not migrated past the northern boundary of Site 1.

Risk Characterization

All compounds detected in the Site 1/AOC B soils and Site 1 groundwater samples which are considered under the Michigan Environmental Response Act 307 were selected as chemicals of potential concern. A site-specific risk assessment was developed only for the future excavation worker exposure scenarios. Guidance developed by the Michigan Department of Natural Resources for residential and generic industrial exposure scenarios were applied to the

direct contact to contaminated soils, and future on- and off-site groundwater ingestion exposure scenarios.

The results for current soil exposures show the reasonable maximum concentration of lead in the surface soils exceeds the generic industrial direct contact criteria for lead, suggesting the current exposure to base personnel from lead in the surface soils should be mitigated. If exposure to the surface soils encompassing location 1SB12 could be mitigated, the 95% upper confidence level lead concentration remaining in the surface soils would be below the NREPA PA 451 industrial cleanup criteria for lead (400 mg/kg). In the future, an unacceptable risk may be present to Site 1/AOC B construction workers through inhalation of arsenic-containing dust.

Future on-site use of the groundwater contained within the surficial aquifer beneath Site 1 should be prohibited based on the occurrence of arsenic and iron within the groundwater samples in concentrations above the generic industrial health-based criteria. Phenanthrene, arsenic, and iron were detected in concentrations exceeding the NREPA PA 451 residential health-based drinking water values. This evaluation assumes future off-site groundwater concentrations will equal the current groundwater concentrations. Using guidelines developed under NREPA PA 451 it was determined that antimony, arsenic, beryllium, lead, and zinc in surface soils and phenanthrene, antimony, arsenic, and beryllium in the subsurface soils could be released or leached from the soils and adversely affect groundwater quality beneath the site. Leachate testing was not completed during this RI. However, leachate testing completed during previous studies shows arsenic at concentrations up to 20 mg/kg does not leach from the soils.

Because of the lack of sensitive habitat present at or around Site 1/AOC B, it is unlikely that ecologically sensitive receptors are present at the site.

Recommendations

The following specific recommendations are presented for Site 1/AOC B:

- Prepare a Feasibility Study which evaluates surface soils around AST 1 (soil boring location 1SB12) and evaluates the future impact contaminated surface and subsurface soils may have upon the Site 1 groundwater.
- Prohibit base personnel from using the Site 1 groundwater as a future source of potable water.
- Periodically monitor Site 1 groundwater concentrations for SVOCs and metals to evaluate if contaminants are being transported off-site in concentrations above NREPA PA 451 residential health-based drinking water values; include the base boundary wells BC-MW6 and BC-MW14, located approximately 300 ft down-gradient of Site 1, in the future monitoring program.

Site 3

Site 3 is located on the western part of the base, southwest of the Civil Engineering storage yard. Fire training exercises were completed at this site from approximately 1977 to 1986 and used approximately 54,000- to 74,000- gallons of a mixture of waste JP-4, oils, hydraulic fluid, and spent cleaning solvents. Site 3 has been the subject of a soils bioventing pilot study (Air Force Center for Environmental Excellence (AFCEE), May 17, 1994) and a groundwater natural attenuation study.

Soil and Groundwater Analytical Results

Site 3 surface and subsurface soil samples collected from inside the bermed area during this RI were only analyzed for PP metals plus barium. The metals barium, cadmium, chromium, lead, and zinc were detected in surface soil samples in concentrations exceeding their

respective background concentrations. These metals were also detected in the 5 to 7 ft bgs intervals, but not in concentrations exceeding background concentrations.

Benzene was detected in the Site 3 groundwater samples above its respective NREPA PA 451 residential health-based drinking values, while antimony was detected in the groundwater samples above background concentrations.

Recommendations

The nature and extent of metals in the surface and near surface soils at Site 3 should be determined. This assessment may be included in the Site 3 activities being completed by the AFCEE, which is addressing groundwater contamination under a natural attenuation study.

Base Boundary Wells

The base boundary wells were installed in 1988 in response to concerns that the base was contributing to groundwater contamination of the drinking water wells north of Dickman Road.

An evaluation of the January 1992 (CDM, June, 1992) and May 1994 groundwater analytical data suggests that there is leachate being generated by a source of groundwater contamination located north of the northern base boundary. This source contains metals (sodium and arsenic) in relatively high concentrations. The presence of arsenic and sodium in the base boundary wells could be attributed to the diffusion or dispersion of leachate generated from a source of groundwater contamination located north of the base boundary wells to the base boundary wells.

Although some of the metal detections found in the base boundary wells may have originated from a source of contamination located north of the northern base boundary, the historic detection of chlorinated solvents, for example trichlorethene and PCE, in groundwater samples collected from wells BC-MW4, BC-MW5, BC-MW6, and BC-MW16 suggest that contaminants are migrating from an unidentified up-gradient location and affecting groundwater quality beneath the base. This location may be either on-base south/southeast (up-gradient) of BC-

MW16, or off-base south/southeast of BC-MW16. The trend of chlorinated VOC concentrations in groundwater samples collected from well BC-MW4, for example, shows that relatively low concentrations of TCE have been detected in successive sampling events. TCE concentrations of 3.2, 4.0, 2.1, and 2.1 $\mu\text{g/l}$ were quantified in samples from BC-MW4 during 1989, 1991, May 1994, and December 1994 sampling events, respectively. These data suggest the TCE concentrations are decreasing slightly. A similar trend in TCE concentrations is evidenced from three rounds of sampling (1989, 1991, and May 1994) completed from well BC-MW5. Although some evidence exists suggesting chlorinated solvent concentrations increase up-gradient from base boundary well BC-BW4, no VOCs were detected in groundwater samples collected from the base boundary wells in concentrations exceeding NREPA PA 451 residential health-based drinking water values. Regardless of the location of the suspected up-gradient source of contamination, the existing network of monitoring wells and the groundwater analytical data obtained from these wells shows that organic compounds (except for bis (2-ethylhexyl) phthalate, a common laboratory contaminant) are not present in the base boundary wells in concentrations exceeding the NREPA PA 451 residential health-based drinking water values.

The metals aluminum, iron, lead and manganese were detected in one or more of the groundwater samples obtained from the base boundary wells in concentrations exceeding background or the residential health-based drinking water values. However, each of these metals were detected above the residential health-based drinking water values in at least one groundwater sample used to calculate the groundwater background (wells BC-MW9, BC-MW11, and BC-MW12). These data suggest the occurrences of these metals are related to variations in the natural groundwater chemistry beneath the site.

Specific recommendations for the base boundary wells are included in the following:

- Prohibit base personnel from using the base groundwater as a source of potable water; aluminum, iron, lead, and manganese concentrations may be elevated locally or regionally above NREPA PA 451 residential aesthetic health-based drinking water values.

- No further remedial action is recommended to characterize groundwater quality base-wide or along the base boundary. This recommendation is based on the May/December 1994 groundwater analytical results which show chlorinated solvent concentrations below NREPA PA 451 residential health-based drinking water values and the trends in the groundwater analytical data. These trends show that in general, concentrations of chlorinated VOCs are decreasing in the groundwater samples obtained from the wells along the northern base boundary.

1.0 INTRODUCTION

This report documents Remedial Investigation (RI) activities that The Earth Technology Corporation (EARTH TECH) performed at the 110th Fighter Wing (FW), Michigan Air National Guard (MIANG), W.K. Kellogg Regional Airport; Battle Creek, Michigan under the U.S. Department of Defense (DOD) Installation Restoration Program (IRP). The field activities described in this report were conducted between October 31, 1994 and May 17, 1995. The following subsections describe the background of the IRP, present the purpose of the RI program, outline the scope of the report, and discuss the methodology of the investigation.

1.1 PURPOSE OF THE INSTALLATION RESTORATION PROGRAM

DOD has initiated the IRP to identify, evaluate, and remediate suspected environmental problems associated with past usage, storage, handling, and disposal of hazardous substances at DOD facilities. Section 120 of the Superfund Amendments and Reauthorization Act (SARA) of 1986 requires that IRP activities adhere to the procedures which are specified in the National Contingency Plan (NCP) Final Rule [55 FR 8666]. The NCP details a sequence of steps to be followed when investigating and cleaning up hazardous waste sites. This sequence begins with the discovery of a suspected hazardous waste release or threat of release and ends with a permanent remedy to eliminate or minimize the environmental impact and long-term monitoring of the remediation effort. The five phases that constitute the IRP process as well as the purpose and activities associated with each phase are presented below:

- Preliminary Assessment - A Preliminary Assessment (PA) is conducted to identify and evaluate the type and location of suspected problems associated with past hazardous waste handling procedures, disposal sites, and spill sites. This is accomplished through interviews with past and present base employees, historical records searches, and visual site inspections. In addition, detailed geological, hydrogeological, meteorological, land use, and environmental data for the area of study are gathered. A detailed analysis of all information obtained identifies areas of concern (AOC). The initial PA for the base was conducted by the Hazardous Materials Technical Center (HMTc) in 1987.

A supplemental PA was completed based on the potential that additional areas exist on base which may have been impacted by past waste handling activities (EARTH TECH, August 1995).

- Site Inspection/Site Investigation (SI) - The purpose of the Site Inspection is to acquire the necessary data to either confirm or deny the existence of contamination at each identified AOC. A SI is similar in purpose to a Site Inspection, but can be expanded to include a preliminary evaluation of the potential risks to human health, welfare, or the environment. Site Inspections can also identify specific chemical contaminants, their concentrations in environmental media, and determine the potential for contaminant migration through site-specific hydrogeologic investigations. A SI for the base was previously conducted by Engineering-Science (ES) in 1991. A Site Inspection for six AOC was completed (EARTH TECH, August 1995) based on the results of the supplemental PA. One of the AOC, AOC B: Motor Pool Drainage Ditch, is contiguous with Site 1 and is included in this RI.
- Remedial Investigation - During this RI the necessary data were acquired to define the extent of confirmed contamination and to assess the associated risks to human health, welfare, or the environment. This RI quantifies the magnitude and the extent of contamination at the sites, as well as identifies the specific chemical contaminants present and their concentrations in environmental media. A determination has also been made as to the potential for contaminant migration by assessing site-specific hydrogeologic and contaminant characteristics. This RI was completed for Site 1: Fuel Tank Farm and the base boundary wells. Additional data were collected in support of the ongoing investigations/remedial actions (RAs) at Site 3: Fire Training Area (FTA).
- Feasibility Study - A Feasibility Study (FS) is performed to develop the RA alternative that mitigates confirmed contamination at each site and meets the applicable or relevant and appropriate requirements (ARARs). The FS considers risk assessments and cost benefit analyses in providing the necessary data,

direction, and documented supportive rationale to acquire regulatory concurrence (federal, state, and local) with the recommended remedial alternative. During the FS, recommendations are evaluated, developed, and provided for RAs at each site where remediation is required.

- Remedial Design - The purpose of Remedial Design is to provide engineering design drawings and construction specifications which are required to implement the recommended RA selected through the FS process.
- Remedial Action - The RA is the implementation of the remedial design. The RA requires appropriate regulation acceptance prior to implementation.

The IRP requires the identification and evaluation of environmentally deleterious sites on DOD installations and the control of adverse effects on human health and the environment from those sites. The Air National Guard Readiness Center (ANGRC), through a U.S. Air Force interagency technical support agreement with the U.S. Department of Energy (DOE), uses Lockheed Martin Energy Systems, Inc. (LMES) to provide technical assistance for the implementation of the Air National Guard (ANG) IRP. EARTH TECH has been retained by LMES under the Hazardous Waste Remedial Actions Program (HAZWRAP) to conduct additional IRP RI activities at the base.

1.2 PURPOSE AND SCOPE OF THIS REMEDIAL INVESTIGATION

The project scope was limited to Site 1: Fuel Tank Farm and Site 3: FTA. These sites were identified during the original PA. Based on information obtained during pre-fieldwork planning, additional sampling activities were completed at Site 3 under the Air Force Center of Environmental Excellence (AFCEE) Bioventing initiative. The scope of the proposed investigations at Site 3 was subsequently modified (see field change request (FCR) # 1 - Appendix A). The base boundary wells, which are not considered a site but which need to be addressed under the IRP process were included in the scope. Field sampling activities were completed and support the preparation of human health and ecological risk assessments for

Site 1: Fuel Tank Farm. No risk assessments were performed for Site 3 or the base boundary wells.

1.3 REPORT ORGANIZATION

This report summarizes the work completed to date, presents and interprets the findings of the investigation (including the risk assessment), and states the conclusions and recommendations reached as a result of the RI activities. This report contains the following sections:

- **Section 1.0 Introduction** - An introduction to the IRP and the RI is presented here.
- **Section 2.0 Installation Description** - Describes the location of the base, its history and organization, and previous IRP activities conducted at the base.
- **Section 3.0 Environmental Setting** - Includes a discussion of the regional climate, the regional and local geology, the regional and local hydrology, and the critical habitats and endangered or threatened species found in the vicinity of the base.
- **Section 4.0 Field Program** - Discusses the general approach of the RI field program and includes variations between the proposed Work Plan (WP) activities and the actual fieldwork performed. Investigation-derived waste and disposal are also addressed in this section.
- **Section 5.0 Investigation Findings** - Presents the laboratory analytical data for the soil and groundwater samples collected during the RI field effort.
- **Section 6.0 Discussion of ARARs** - Presents a discussion of the Michigan National Resources and Environmental Protection Act (NREPA) 451 regulations and their applicability to this RI.

- **Section 7.0 Significance of Results** - The significance of results, including the risk characterization, are presented in Section 7.0.
- **Section 8.0 Conclusions** - Conclusions based upon the findings and significance of results are presented in Section 8.0.
- **Section 9.0 Recommendations** - Recommendations are presented in Section 9.0.
- **Section 10.0 References** - References are included in Section 10.0.

Additional information that can be found in this RI report includes a list of acronyms and abbreviations, appendices detailing the soil and groundwater screening results, boring logs, groundwater sampling and analysis forms and analytical reports. FCR and chain-of-custody (COC) forms are also provided.

2.0 FACILITY BACKGROUND

The following sections briefly describe the base location, summarize the base history and organization, and discuss previous IRP activities.

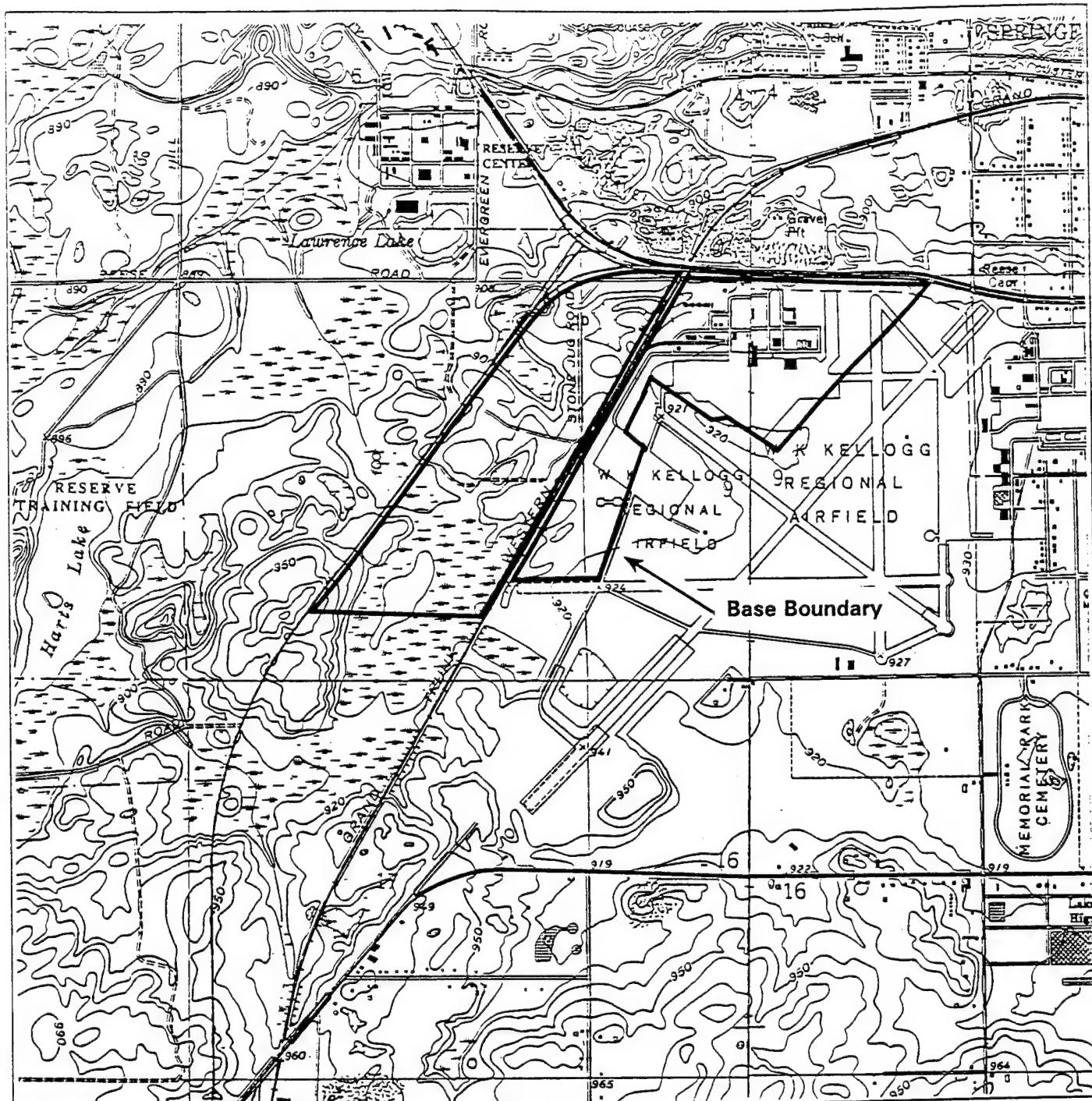
2.1 BASE LOCATION

The base is located in south-central Michigan at the W. K. Kellogg Regional Airport in southwest Battle Creek (Figure 2-1). Battle Creek is located in Calhoun County, approximately 100 miles west of Detroit and 20 miles east of Kalamazoo. The base occupies 315 acres in the northwestern portion of the airport, approximately 204 acres of which are separated from the main portion of the base by the Grand Trunk Western Railroad (Figure 2-2). Runway facilities at the airport are used jointly for military and civilian purposes.

2.2 ORGANIZATION AND HISTORY

Prior to 1924, the property on which the base is located was used for agricultural purposes. In September of 1924, a lease with an option to buy the property was signed by the Battle Creek Chamber of Commerce. Four years later, W. K. Kellogg donated the necessary money to purchase and make improvements to the site. The Army Air Corps utilized the airport for combat duty training and to stage crews for overseas deployment from 1942 until 1946. During this time, new runways were constructed and existing runways were lengthened. Buildings were also erected to house base personnel and to support military functions. In 1986, the area that the base occupied was increased from approximately 90 acres to 315 acres.

The very same year that the Army Air Corps ceased using the airport, the 172nd Fighter Squadron of the MIANG was formed and Kellogg Field was designated as its headquarters. In 1951, the unit was called to active duty as part of the 56th Fighter Wing at Selfridge Air Force Base in Michigan. The unit was redesignated as the 172nd Fighter Bomber Squadron when it returned to Kellogg Field the following year. In 1955, the unit was reorganized as the



SOURCE: USGS 7.5 MINUTE QUADRANGLE(S) FOR
BATTLE CREEK, AUGUSTA (1981) PHOTO REVISED 1985

LATITUDE: 42° 18' 45" N
LONGITUDE: 85° 19' 00" W
UTM CO-ORDINATES: 6440000 MN 4688000 E

SCALE 1:24,000

1 1/2 0 1 MILE

1 0 1000 2000 3000 4000 5000 6000 7000 FEET

DRAFT

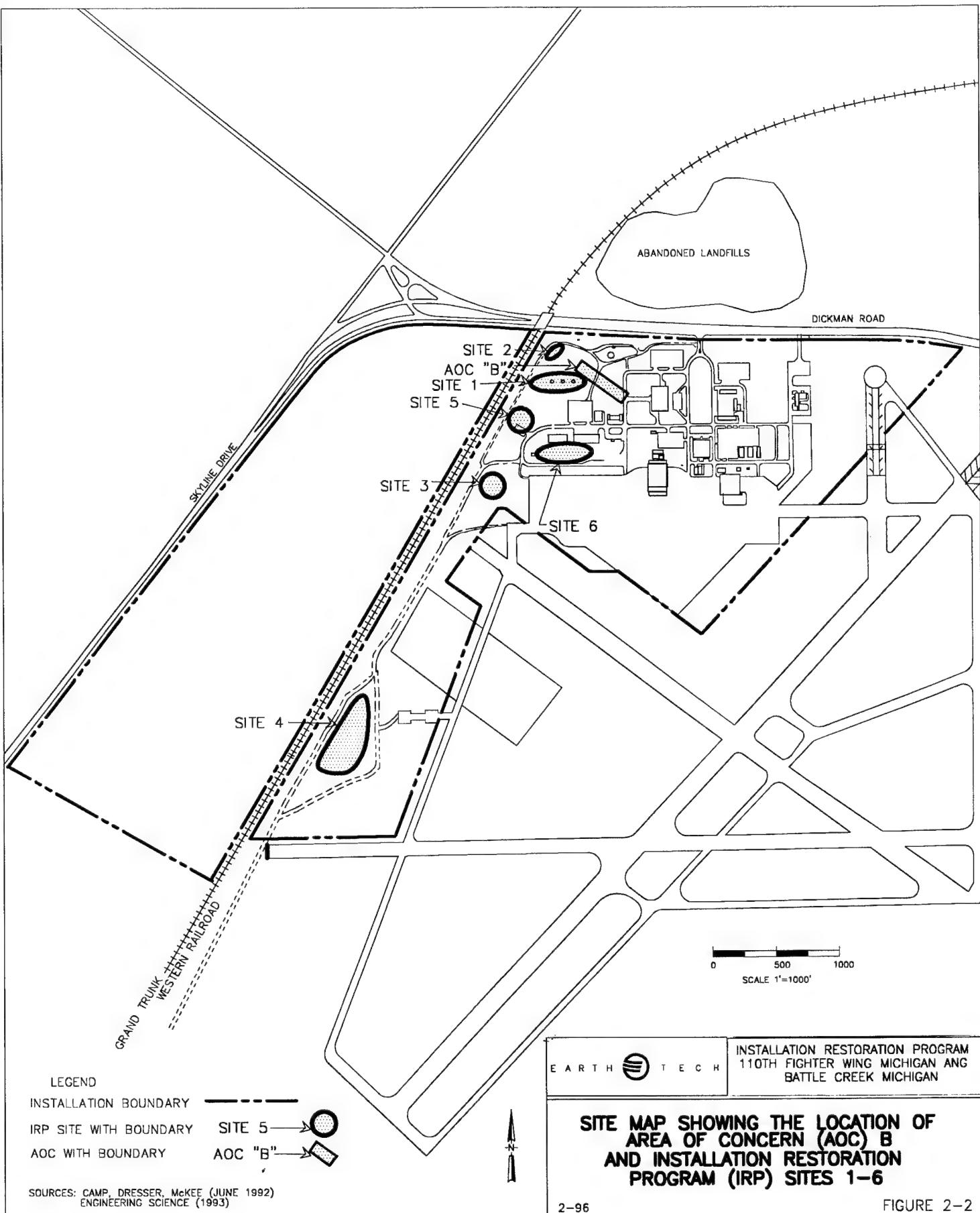
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN
LOCATION MAP

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Figure 2-1



172nd Fighter Interceptor Squadron which was upgraded to the 110th Fighter Group (FG) the very next year. This unit was deactivated and redesignated the 172nd Tactical Reconnaissance Squadron two years after it had been upgraded. In 1962, the base was reorganized again, and the 172nd Tactical Reconnaissance Squadron became the 110th Tactical Reconnaissance Group. This unit was replaced by the 110th Tactical Air Support Group in 1971. In 1992, the unit was reorganized as the 110th FG and assigned the A-10 aircraft which it currently operates. The 110th FG was renamed the 110th FW in August 1995. Throughout its history, the base has stored and used various types of potentially hazardous materials in support of its primary fighter mission.

2.3 PREVIOUS IRP ACTIVITIES

Previous IRP activities are discussed in the following subsections. In addition to the IRP activities at the base, an Environmental Assessment (EA) of the base area was conducted by Hickok and Associates (Hickok, 1985). The EA did not address potential contamination due to the past activities of existing facilities on the base.

2.3.1 Preliminary Assessment

An IRP Phase I PA was conducted in 1987 to identify and assess past operations at the base that may have involved storage or disposal of hazardous materials or wastes (HMTC, 1987). The purpose of the assessment was to evaluate the potential for environmental releases from hazardous materials and waste management practices. Six sites (as described in Section 2.3.3) were identified as potential sources of contaminant release and were recommended for further investigations. Sites 5 and 6 were identified after completion of the PA.

2.3.2 Immediate Response Investigation

Upon completion of the PA, an Immediate Response Investigation (ES, 1988) was conducted to assess groundwater quality at the base boundary. Fifteen monitoring wells (BC-MW1 through BC-MW15 along the northern base boundary and southwest of the base were installed, sampled, and analyzed. These groundwater samples were analyzed for volatile

organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and priority pollutant (PP) metals. VOCs and elevated concentrations of metals were detected in several of the samples.

After the Immediate Response Investigation report was finalized, the analytical data became suspect. A laboratory audit showed numerous problems with the laboratory's quality assurance (QA) and quality control (QC) procedures. These problems are addressed in the QA report for the Site Investigation analyses conducted in 1988 (ES, November 1993).

2.3.3 Site Investigation

A SI was completed for the four sites (Sites 1 through 4) identified during the PA and for Sites 5 and 6, which were added to the SI after completion of the PA. The locations of Sites 1 through 6 are presented on Figure 2-2. The SI recommendations for the six sites are presented in the following:

- Site 1: Fuel Tank Farm: The removal of contaminated soil was recommended for Site 1. The ANGRC determined that additional soil and groundwater sampling was necessary prior to RAs, if appropriate, for Site 1. Site 1 has been included in this RI.
- Site 2: Drainage Swale: A FS was recommended for Site 2. A Source Removal Action Plan (SRAP) and Plans and Specifications for capping the swale have been developed for Site 2 by ES (July 1994). This RA was implemented during the fall of 1995.
- Site 3: FTA: A FS was recommended for Site 3. The site was selected for a bioventing pilot study, which was initiated in September 1992 (ES, November 1992) and completed in May 1994 (Air Force Center for Environmental Excellence, May 17, 1994). Site 3 has been included in the RI.

- Site 4: Abandoned Landfill: A Decision Document stating that no further action is required was recommended for Site 4.
- Site 5: Former Coal Storage Area: A removal action was recommended for Site 5. A SRAP and Plans and Specifications for capping the area has been developed for Site 5 by EARTH TECH (July 1994). This RA was implemented during the fall of 1995.
- Site 6: Fuel Spill: A Decision Document stating that no further action is required was recommended for Site 6.

2.3.4 Preliminary Assessment/Site Inspection

A supplemental base-wide PA was initiated during October 1993. The PA identified six AOC on base. A Site Inspection, consisting of a soil organic vapor survey and soil sampling and analysis was completed for the six AOC identified during the PA. A Draft Final PA/Site Inspection Report was completed by EARTH TECH, August 1995. One of the six AOC, AOC B: Motor Pool Drainage Ditch, borders Site 1 (Figure 2-2). Because of the proximity of the two areas, the AOC B soils are included with Site 1 in this RI.

2.3.5 Source Removal Actions

SRAPs (similar in scope to Focused Feasibility Studies (FFSs) were developed for Sites 2 and 5 during the fall 1993 through summer 1994 time period. The recommendations for each of the SRAPs are as follows:

- Site 2: Drainage Swale: A cap, consisting of an earthen cover, and diversion of surface water from the site was recommended for Site 2 (ES, July 1994).
- Site 5: Former Coal Storage Area: A cap, consisting of an asphalt cover, and stabilization of heavy metals present in the soils was recommended for Site 5 (EARTH TECH, July 1994).

Plans and Specifications have been prepared for both Sites 2 (ES, July 1994) and 5 (EARTH TECH, July 1994) and these interim RAs are scheduled to be completed during the fall of 1995 - spring of 1996 time period.

2.4 SITE DESCRIPTIONS

Site descriptions, including a summary of the previous sampling results, for Sites 1 and 3 and the base boundary wells are included in the following subsections.

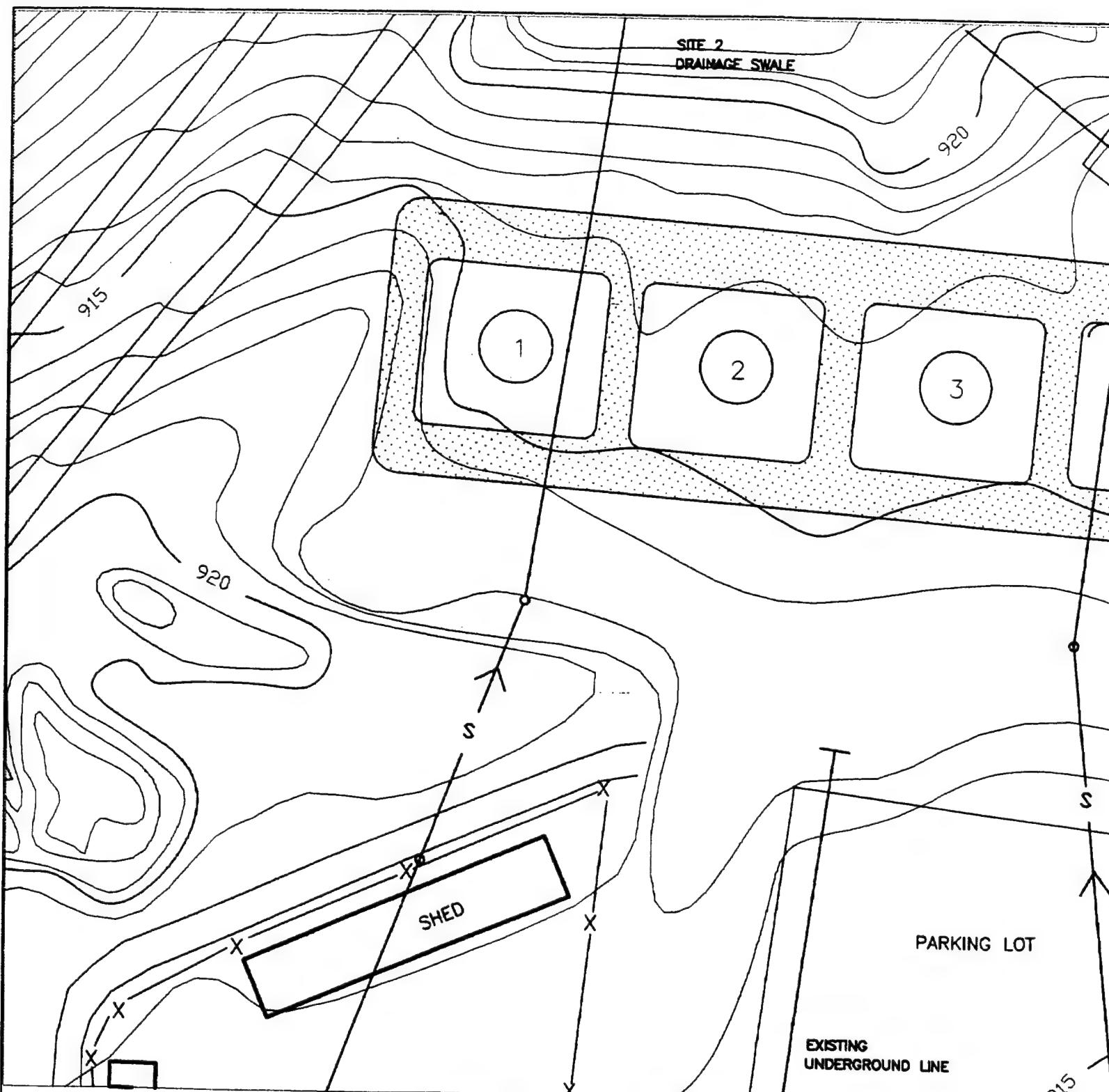
2.4.1 Site 1: Fuel Tank Farm

Site Description

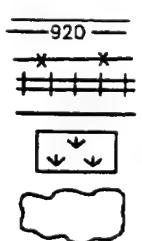
Four 25,000-gallon aboveground storage tanks (ASTs) were located near the drainage swale, northwest of the Motor Pool parking lot (Figures 2-2 and 2-3). The ASTs were used for storage of gasoline prior to 1949 but were not used between 1949 and 1973. During 1973 and 1974, they were used by the city of Battle Creek for storage of No. 4 heating fuel. The ASTs were patched prior to use by the city, and heating fuel reportedly leaked at some of the patches. The site is generally flat and grass-covered. To the north the ground surface slopes into the drainage swale (Site 2). Two storm sewer lines (Figure 2-3) cross the area. The piping associated with the ASTs ran along the southern edge of the four ASTs. This piping was joined next to AST 3 by a north-south trending underground pipe running from the underground storage tanks (USTs) at Site 6 to these ASTs (Figure 2-3).

The Motor Pool Drainage Ditch (AOC B is identified in the PA/Site Inspection borders Site 1 on the east side (Figure 2-3). The building which houses the Motor Pool was constructed in 1963. The building is not shown on Figure 2-3; however, it is located immediately south of the parking lot shown in the southeastern corner of this figure. Routine vehicle maintenance activities (oil changes, etc.) occur in the facility for approximately 100 vehicles. The vehicle types serviced by the Motor Pool range in size from automobiles to 15-ton trucks. The facility is equipped with an oil/water separator (OWS) located beneath the eastern portion of the Motor Pool Building.

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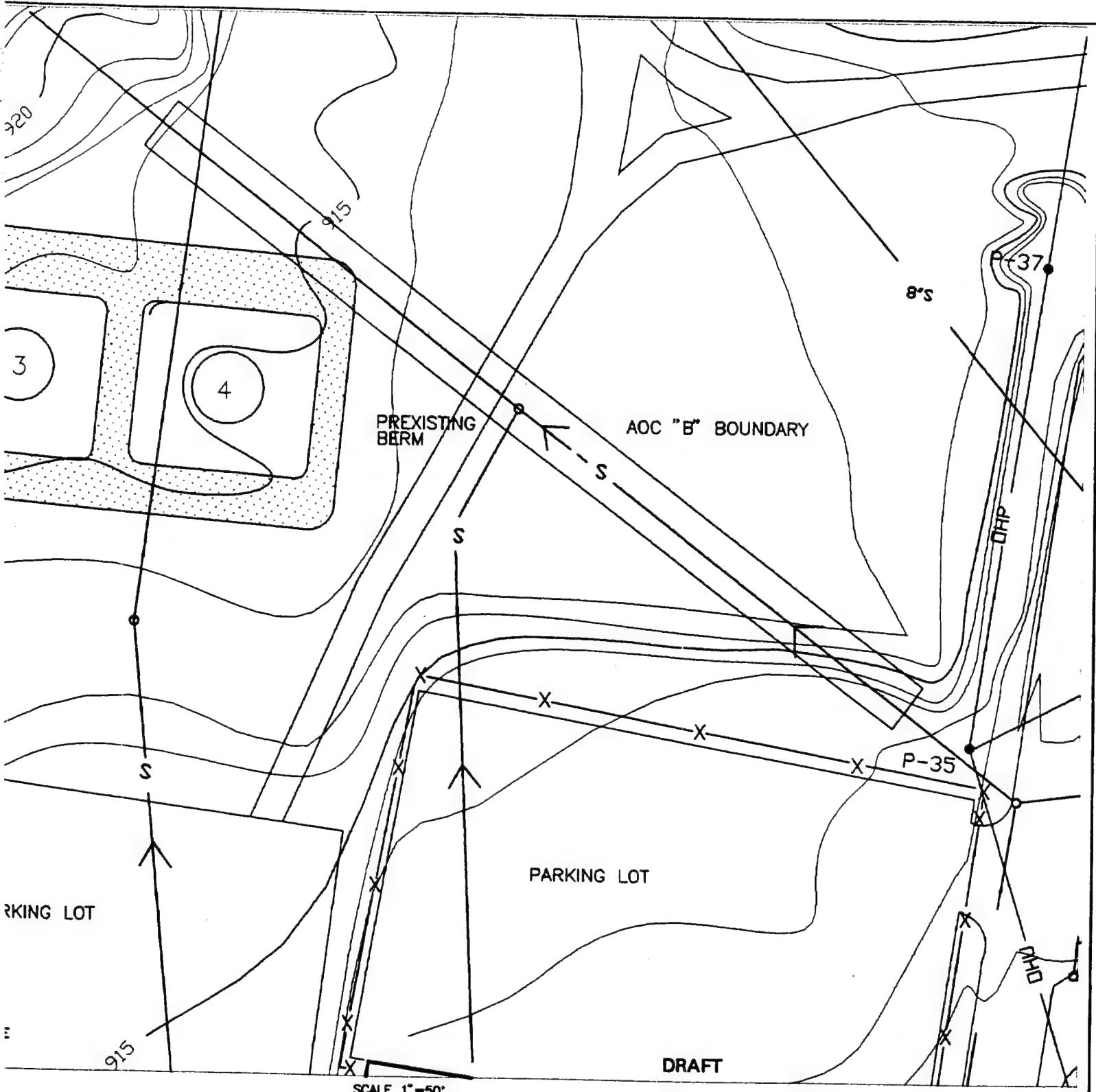
**LEGEND**

T	Telephone
OHU	Overhead Utilities
F	Fire Alarm
C	Communication
SL	Sanitary Sewer Line
SG	Storm Drains
G	Gas
W	Water



Topographic
Contours
Fence
Railroad
Stream
Grass
Trees

- 3 Above Ground Storage Tank (Pre-existing)
- 310 Building with ID Number
- Roads

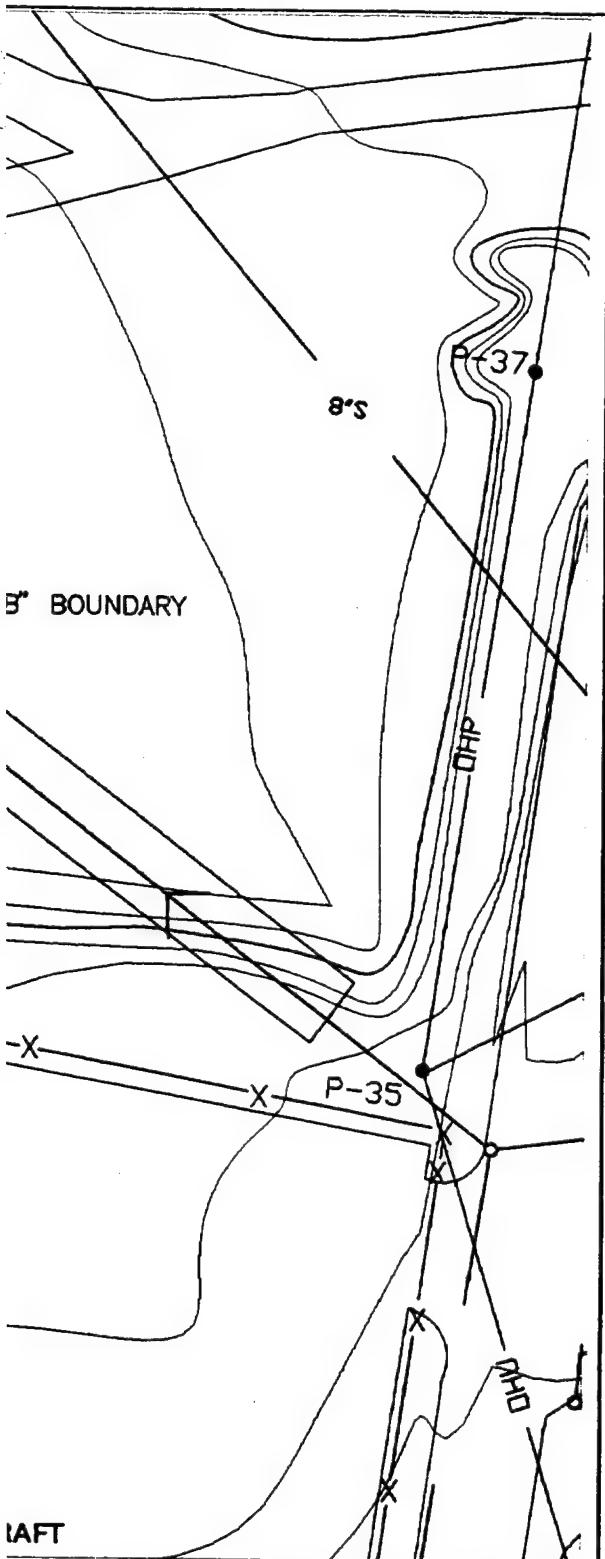


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INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 1
SITE PLAN

(3)



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 1
SITE PLAN

FIGURE 2-3

Reportedly, the OWS was an original part of the Motor Pool. Prior to 1985, an open ditch ran from the northwest corner of the Motor Pool parking area to the drainage swale (IRP Site 2). Drainage features are illustrated on Figure 2-3. In 1985, a storm sewer (concrete pipe) replaced the ditch and the ditch was filled in. From 1963 to 1992, the overflow from the OWS in the Motor Pool Building entered the ditch via a concrete drain. In 1992, the overflow from the OWS was rerouted to the sanitary sewer system.

Base personnel indicated that it was never a common practice to directly dispose of waste Petroleum, Oil, and Lubricants (POL) in the ditch. However, sediment samples collected from the outfall of the old drainage ditch contained VOCs, polynuclear aromatic hydrocarbons (PAHs), and various metals (ES, November 1993). These data suggest that the ditch has, in the past, carried contaminated run-off. In addition, it was reported that stained soils were observed by construction personnel when the storm sewer was installed in the course of the ditch.

Motor Pool personnel indicated that a majority of the waste POL generated during maintenance activities was not disposed of through the OWS. The OWS was generally full and reportedly not pumped out regularly. However, during the period of 1972 through 1993 while refueling trucks were being serviced in the Motor Pool, approximately 50 gallons per year of JP-4 jet fuel was disposed of through the OWS. Additionally, a variety of operations involving waste POL were conducted in the parking area behind the facility, including the cleaning of engines and vehicles. The parking area was routinely washed and the resulting wastewater flowed into the ditch. Based on its proximity to Site 1, AOC B has been included in this RI.

Previous Sampling Results

The SI soil sampling results from 1988 were not useable due to poor data quality and lack of laboratory QA/QC procedures (ES, November 1993). Although soil contamination at Site 1 was not quantified, the data did indicate the presence of petroleum products in the soil. Soil staining and petroleum odor were noted during drilling operations. The previous sampling locations and the area in the soils where fuel contamination was tentatively identified during

the SI are included on Figure 2-4. Monitoring well BC2-MW1, located down-gradient of Site 1, was free of contamination associated with fuels. Prior to the PA/Site Inspection (EARTH TECH, August 1995), there were no sampling results for AOC B.

2.4.2 Site 3: Fire Training Area

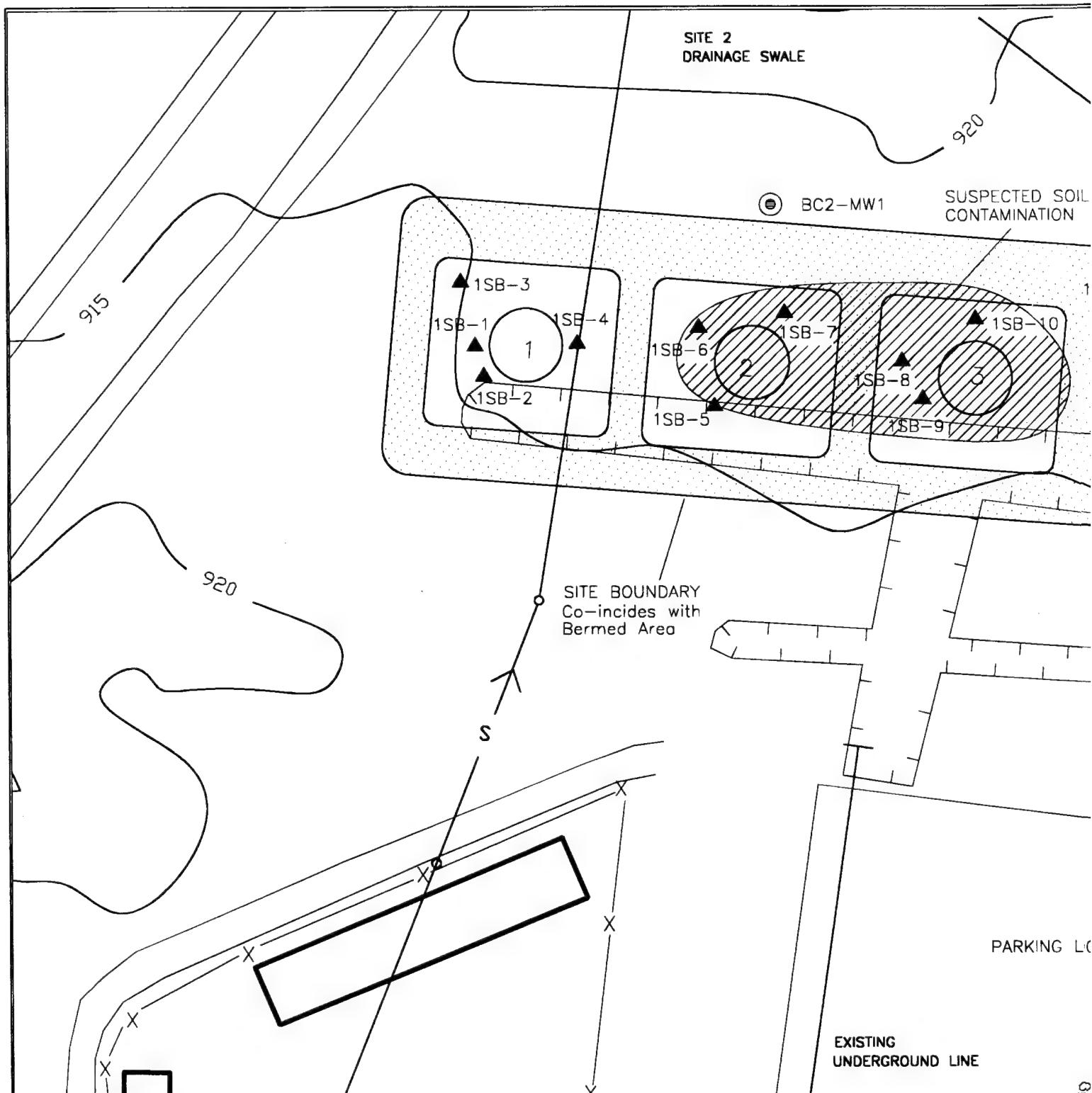
Site Description

Site 3 is located on the western part of the base, southwest of the Civil Engineering storage yard (Figures 2-2 and 2-5). The site is generally flat and is grass- or gravel-covered. The FTA is approximately 85 ft in diameter and surrounded by an earthen berm. Fire training exercises were conducted at this site from approximately 1977 to 1986. Approximately 54,000 to 74,000 gallons of a mixture of waste JP-4, oils, hydraulic fluid, and spent cleaning solvents were reportedly burned during fire training exercises (HMTC, 1987). The mixture of wastes was floated on top of water, ignited, and extinguished. An area where drums of waste were stored prior to utilization in fire training exercises is located north of the FTA.

Previous Sampling Results

The 1988 SI data indicated high concentrations of fuel constituents in the soil. Lead was detected in concentrations estimated to exceed NREPA PA 451 Type A default criteria. The site was selected for a bioventing pilot study which was initiated in September 1992 (ES, November 1992). Soil sampling results completed prior to the installation of the bioventing system indicated that the maximum soil benzene, toluene, ethylbenzene, and xylene (BTEX) and total petroleum hydrocarbons (TPH) concentrations in the Site 3 soils were 32.8 mg/kg and 15,000 mg/kg, respectively. The one-year duration pilot study results show that BTEX concentrations and TPH concentrations have decreased significantly in the Site 3 soils (Air Force Center for Environmental Excellence, May 17, 1994). Previous sampling locations and a layout of the bioventing pilot study injection well and vapor monitoring locations are included on Figure 2-6.

1



LEGEND

- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- S Storm Drains
- G Gas
- W Water

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Topographic
Contours

Fence

Railroad

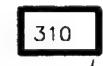
Stream

Grass

Trees



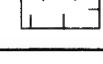
Above Ground
Storage Tank
(Pre-existing)



Building with ID Number



Roads



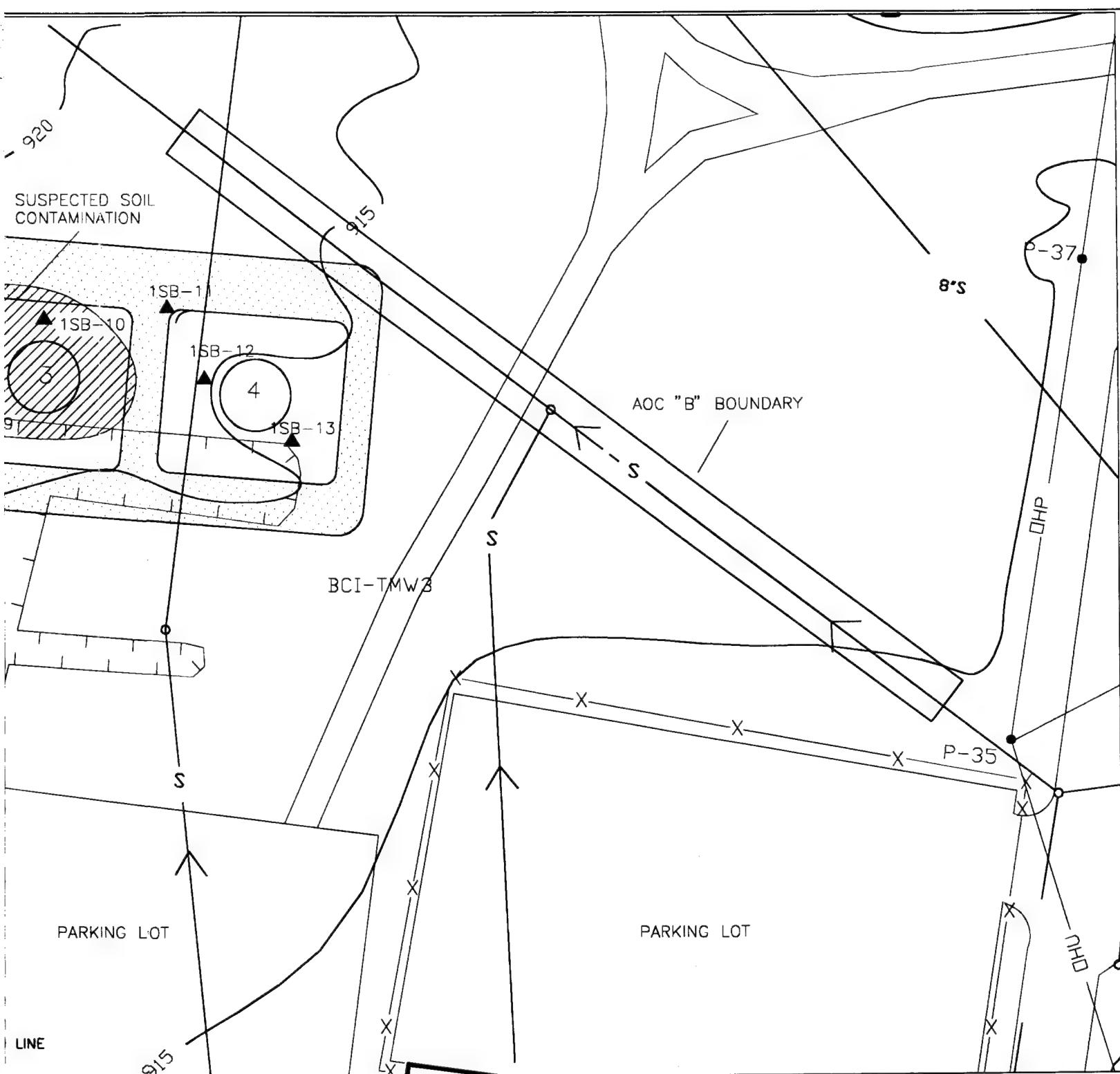
Excavated in 1992



Surface Boring L
(ES 1993)

Existing Monitor

(2)



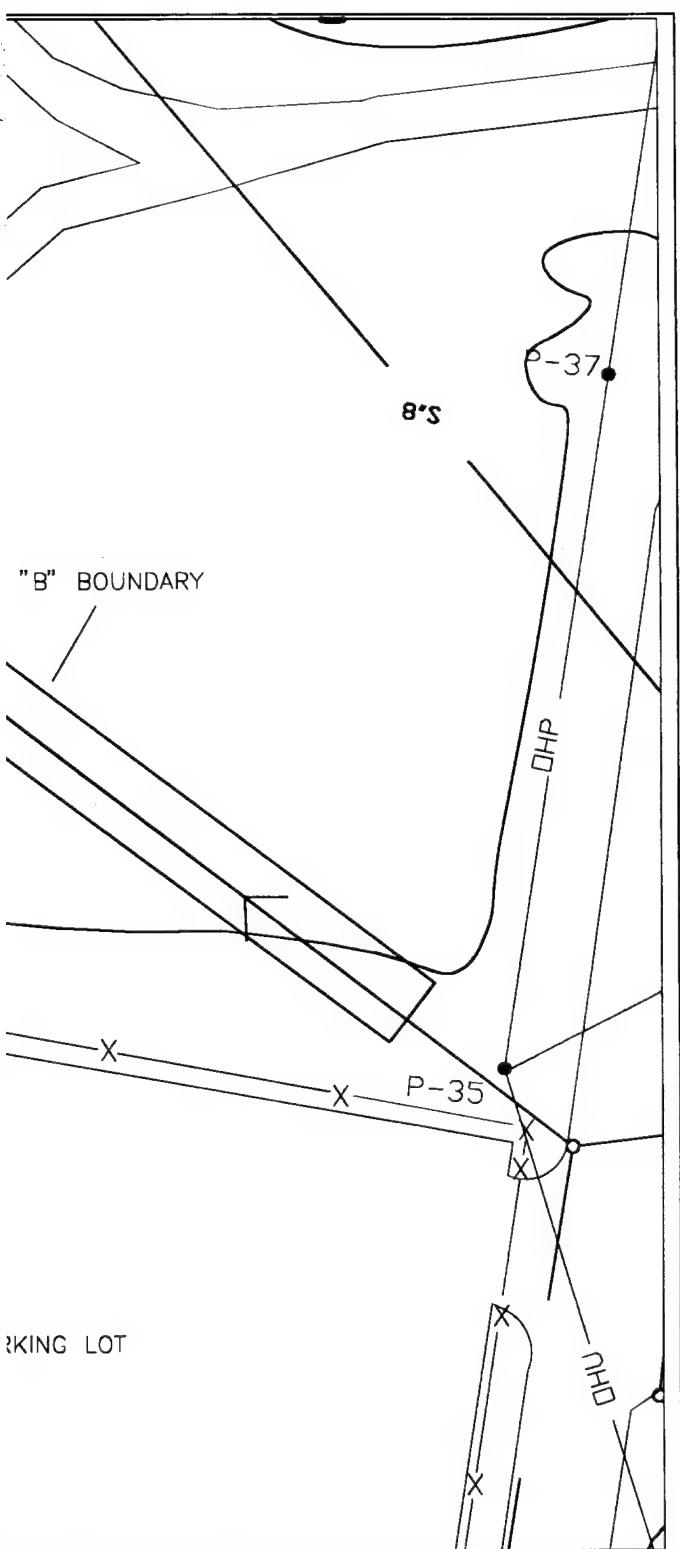
Surface Boring Location
(ES 1993)
Existing Monitoring Well

Scale 1"=50'



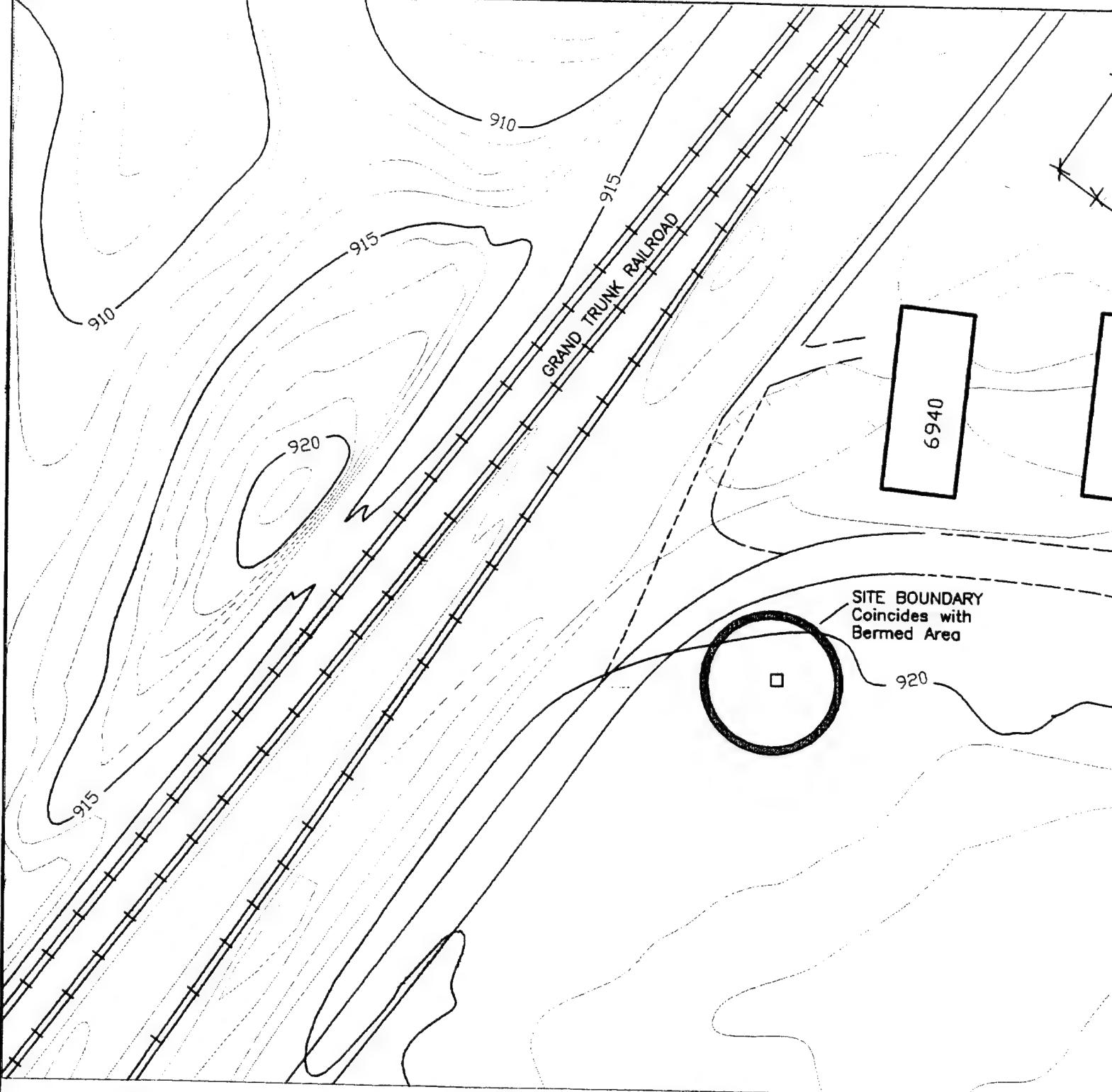
INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 1 PREVIOUS SAMPLING LOCATIONS



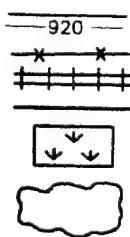
INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 1
PREVIOUS SAMPLING LOCATIONS**



LEGEND

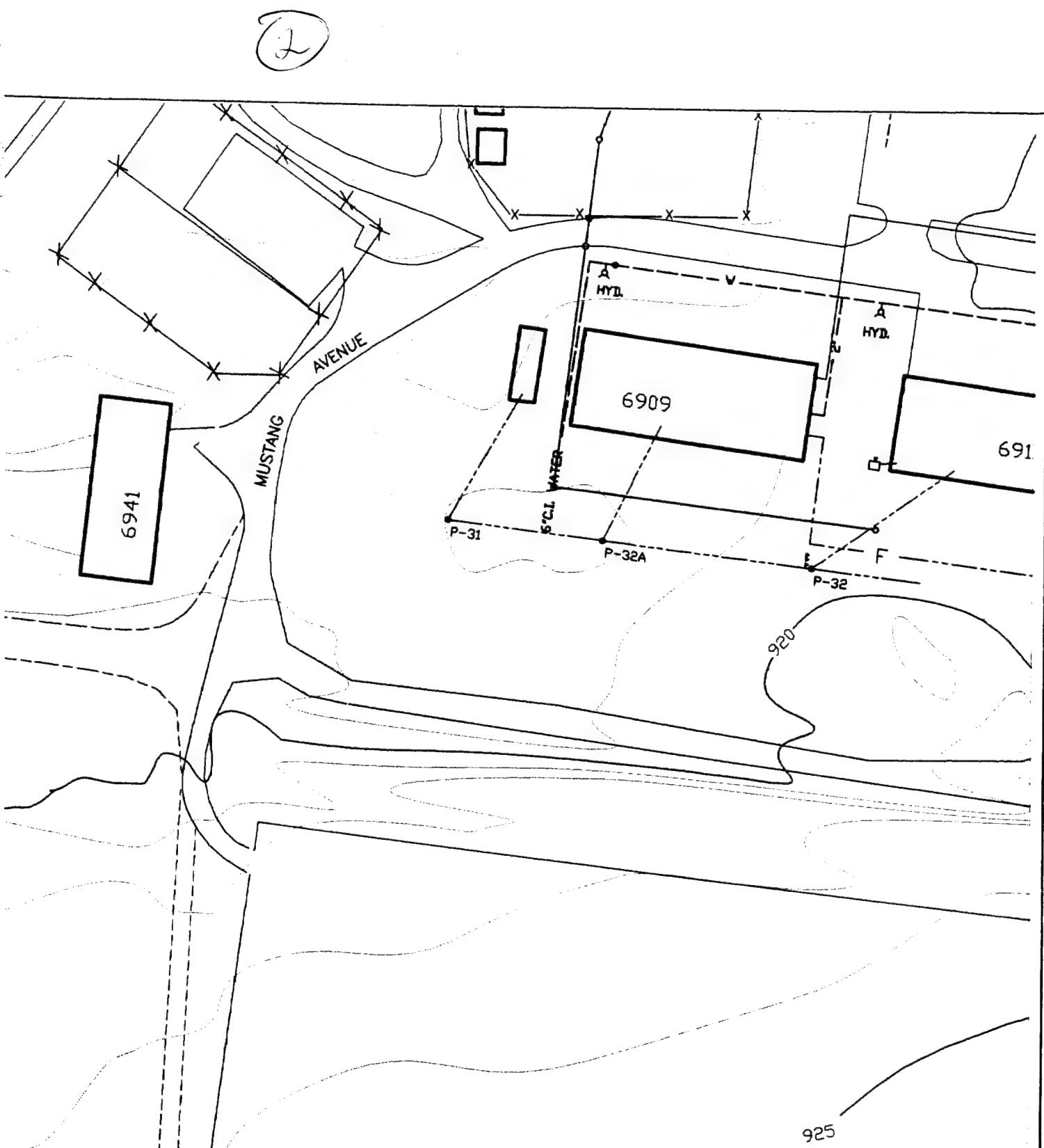
- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- SS Storm Drains
- GW Gas
- W Water



- Topographic Contours
- Fence
- Railroad
- Stream
- Grass
- Trees



- Above Ground Storage Tank (Pre-existing)
- Building with ID Number
- Roads

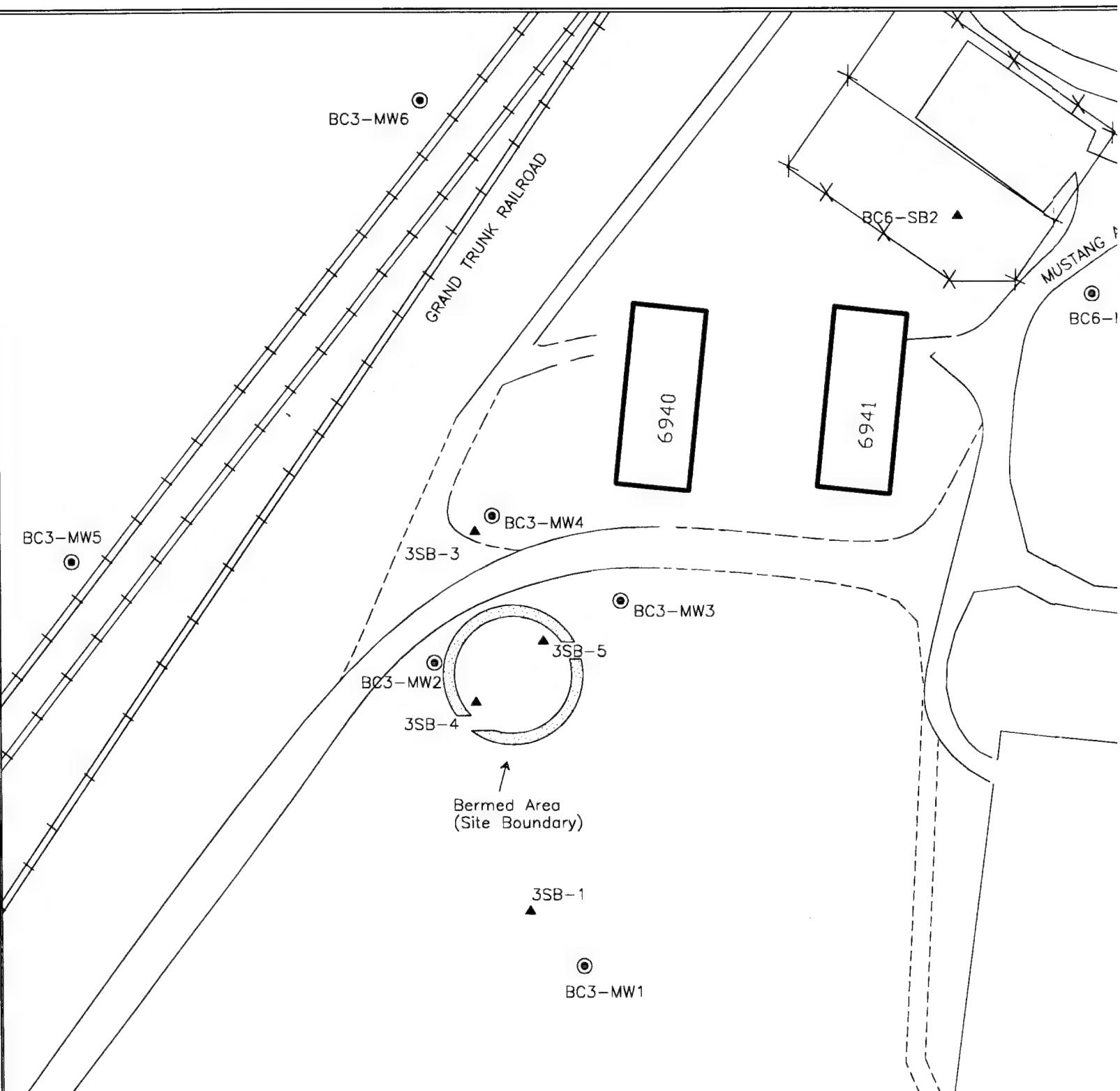


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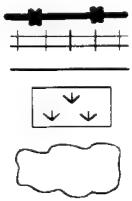
INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 3
SITE PLAN

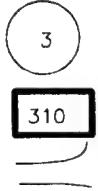
1

**LEGEND**

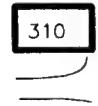
T	Telephone
OHU	Overhead Utilities
F	Fire Alarm
C	Communication
SL	Sanitary Sewer Line
S	Storm Drains
G	Gas
W	Water
E	Electrical



Fence
Railroad
Stream



Above Ground
Storage Tank
(Pre-existing)



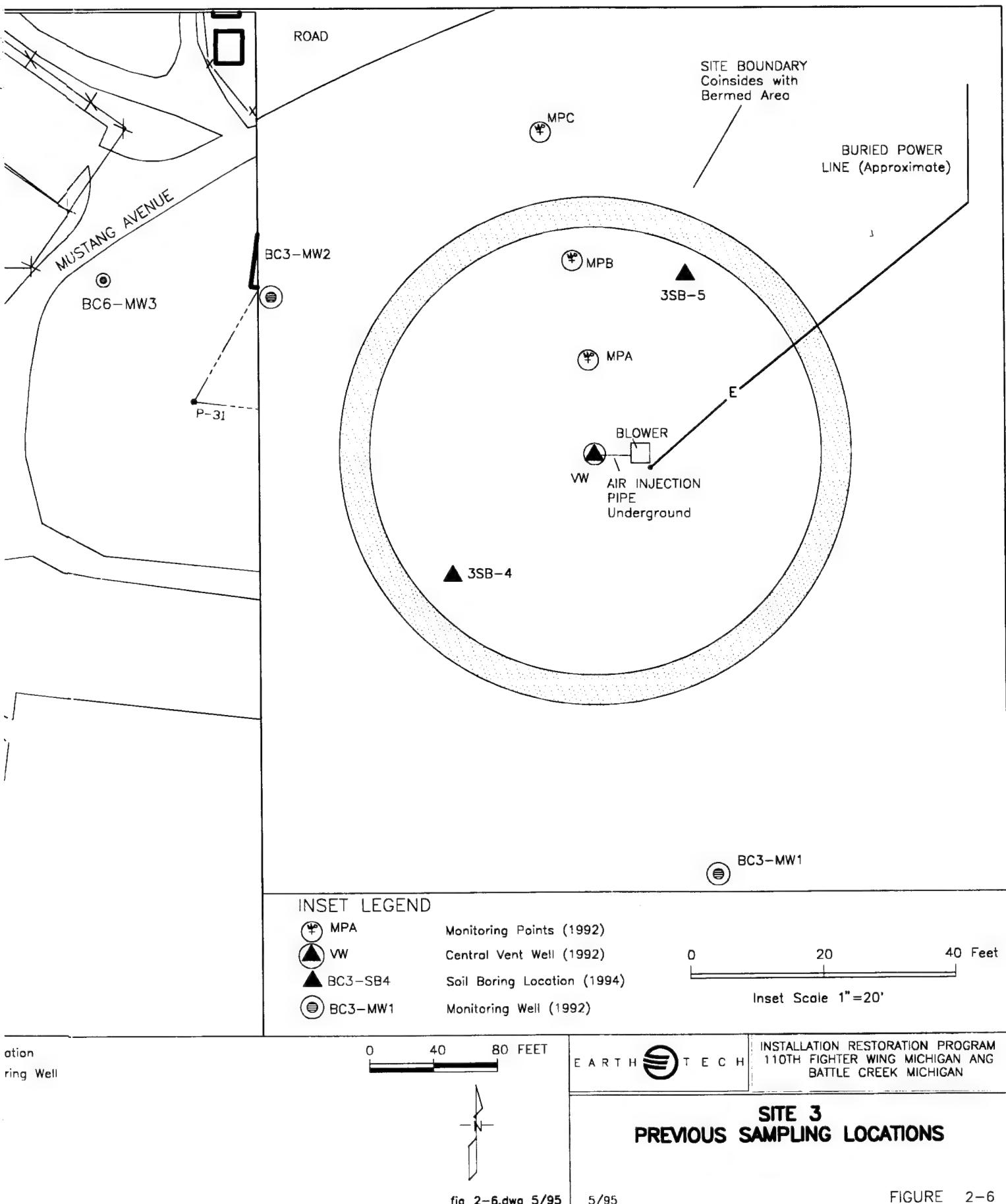
Building with ID Number

Roads



Soil Boring Location
Existing Monitoring Well

(2)



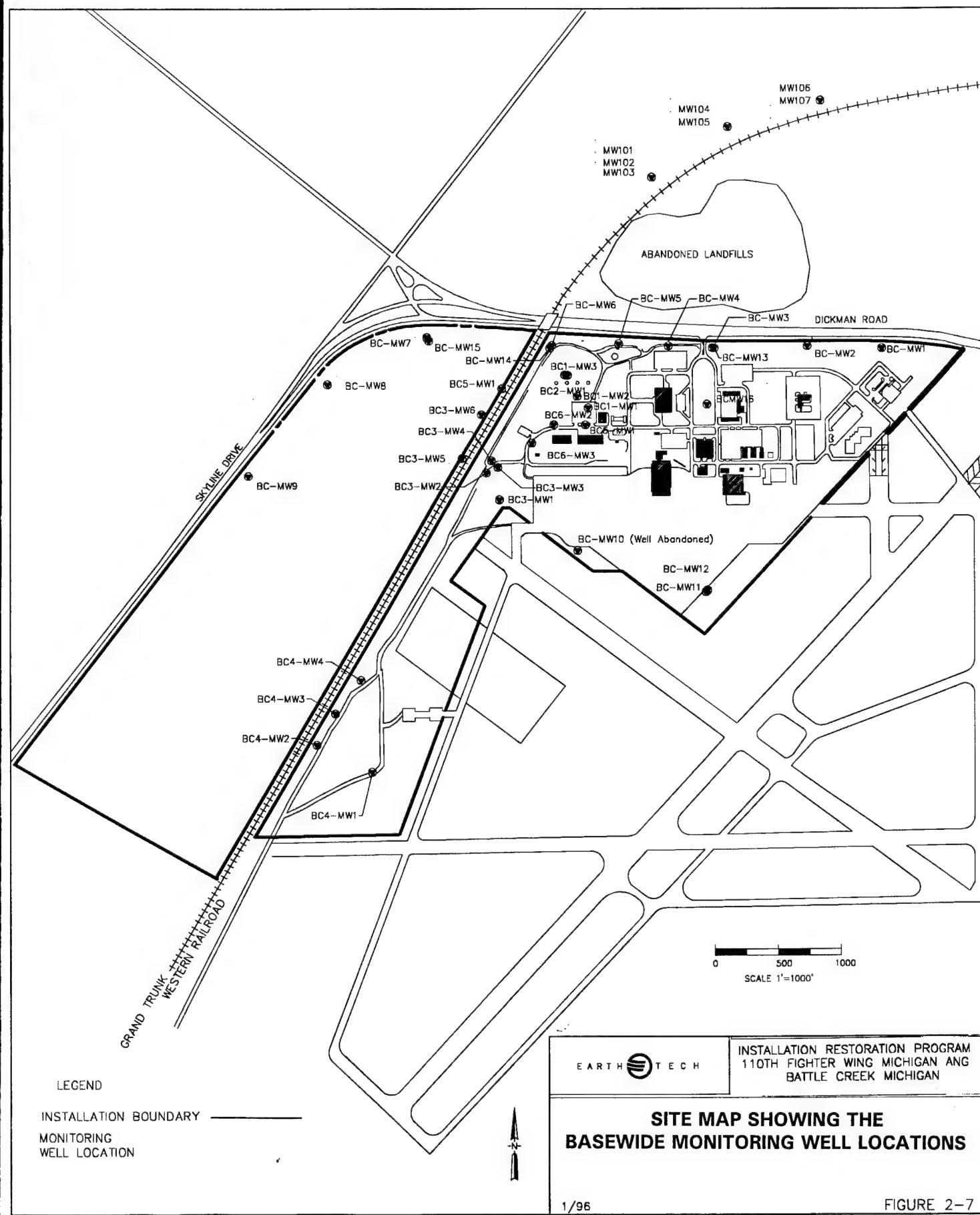
2.4.3 Base Boundary Wells

Site Description

The base boundary wells were installed in 1988 in response to concerns that the base was contributing to groundwater contamination of the drinking water wells north of Dickman Road. The base boundary wells included in this RI are BC-MW1 through BC-MW15 (Figure 2-7). The location of two abandoned landfills/dumps north of, and across from, Dickman Road are also indicated on Figure 2-7. These landfills have been identified as a suspected source area for the groundwater contamination detected in the drinking water wells north of Dickman Road (Camp Dresser and McKee, June 1992).

Previous Sampling Results

Three groundwater sampling rounds have confirmed the presence of Trichloroethene (TCE) in concentrations greater than the pre-existing Michigan Environmental Response Act 307 (MERA) Type B criteria for groundwater and 1,1,2,2-Trichloroethane (TCA) and zinc in concentrations above other health-based criteria (ES, November 1993).



3.0 ENVIRONMENTAL SETTING

A complete discussion of the base environmental setting will be presented in the following subsections.

3.1 METEOROLOGY

The Battle Creek region is characterized by a climate that is predominately continental in nature, although it frequently alternates between continental and semi-maritime conditions. Continental climates are characterized by pronounced differences in seasonal temperatures (i.e., hot summers and very cold winters). Semi-maritime climates experience moderate temperatures during the winter and summer. The variable nature of seasonal weather patterns in the area is caused by winds originating from the Great Lakes. When these winds extend into the Battle Creek region, the continental climate is replaced by a semi-maritime climate (HMTC, June 1987).

The Battle Creek area has an annual precipitation of 30.73 in., based on the period from 1956 to 1985. Precipitation is fairly well distributed through the year, with the heavier amounts occurring as thunderstorms during May and June. Snowfall for the Battle Creek area is moderate, averaging about 52 in. per year (HMTC, June 1987).

Net precipitation was calculated according to the method outlined in the Federal Register (47 FR 31224, 16 July 1982), and was presented in the PA. A net precipitation value of 0.73 in. per year was obtained. Rainfall intensity, based on one-year frequency, 24-hour duration, is 2.25 in. (calculated according to 47 FR 31235, 11 July 1982 cited in HMTC, June 1987).

3.2 PHYSIOGRAPHY AND TOPOGRAPHY

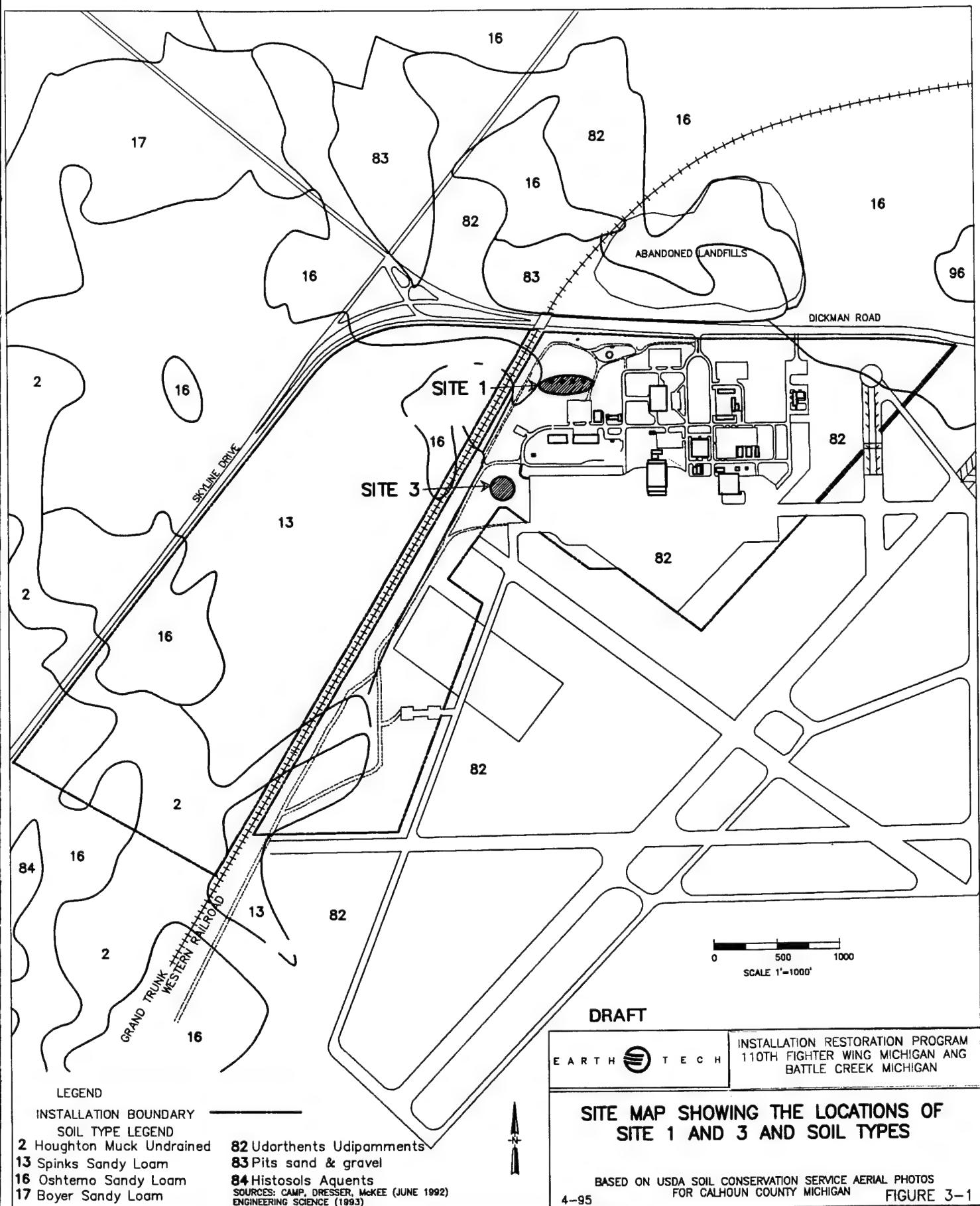
The base is located within the Central Lowland Physiographic Province of the Interior Plains. This region is characterized by its vast plain, relatively low altitude of 500 to 2000 ft above mean sea level (AMSL), and slight local relief.

The base consists of large paved areas and has a gently rolling to nearly flat topography (Figure 2-1). The mean elevation of the airport area is 941 ft AMSL (Hickok, 1985). Wet swampy areas occur in the portion of the installation west of the railroad tracks. Elevations on the western property range from 890 to 920 ft AMSL.

3.3 SOILS

The soils at Battle Creek are comprised primarily of five soil series, which have been given the United States Department of Agriculture (USDA) Soil Conservation Service names Houghton, Spinks, Oshtemo, Boyer, and Udorthents. The distribution of these soils within the vicinity of the base is shown on Figure 3-1. These soil series are described as follows:

- **Houghton Series**, 0 to 2% slopes - This mapping unit consists of very poorly drained soils that were formed in herbaceous organic deposits, bogs, and other depressional areas within outwash plains, lake plains, till plains, and moraines.
- **Spinks Series**, 0 to 18% slopes - This mapping unit consists of very deep, well-drained soils formed in glaciofluvial deposits on moraines, till plains, beach ridges, and outwash plains.
- **Oshtemo Series**, 0 to 18% slopes - This mapping unit consists of well-drained soils formed in loamy and sandy glaciofluvial deposits on outwash plains and moraines.
- **Boyer Series**, 0 to 12% slopes - This mapping unit consists of very deep, well-drained soils formed in loamy and sandy glaciofluvial deposits on outwash plains, deltas, valley trains, and moraines.
- **Udorthents**, 0 to 2% slopes - This mapping unit consists of well-drained to excessively drained soils which have been mixed by land leveling, filling, or excavation.



In general, the permeability of these soils ranges from moderate (4.2×10^{-4} to 1.4×10^{-3} cm/sec) to rapid (4.2×10^{-3} to 1.4×10^{-2} cm/sec).

3.4 GEOLOGY

The regional and local geologic settings of the area will be presented in the next two subsections.

3.4.1 Regional Geology

South-central Michigan, including the base, is located within the Michigan Basin of the Central Lowland Physiographic Province. A plain of Pleistocene-aged (Wisconsin Series) glacial advance deposits covers the Battle Creek area. Valleys and morainal ridges arranged in concentric arcs around the ends of the Great Lakes interrupt this plain. A regional stratigraphic column is shown on Figure 3-2.

Bedrock in the Michigan Basin (Figure 3-3) is Pennsylvanian-aged in the center and Cambrian-aged at the outer boundary of the basin. The geologic structure of the basin is expressed as small folds, fractures, and faults. These minor structural features are generally oriented to trend northwest - southeast in the Battle Creek area. Offsets in the trend of buried valleys and major bends in the Battle Creek River suggest folds, fractures, faults, or a combination of all three (Grannemann and Twenter, 1985).

In southern Michigan, the Pleistocene-aged glacial deposits consist of till, outwash, and channel deposits derived principally from fragments of sandstone and shale deposited as the last continental glacier retreated across Michigan. Composition and mode of deposition (glacier or meltwater) differentiated these deposits of sand, silt, clay, gravel, and boulders. The glacial deposits in the area range in thickness from a few feet to greater than 100 ft. The glacial deposits overlie the Paleozoic sedimentary bedrock which consists of sandstone, siltstone, and shale.

Geologic Unit		Lithologic Characteristics	Hydrologic Unit
Marshall Formation	Glacial deposits	Sand and gravel Bedrock surface	Sand and Gravel Aquifer
	Upper sandstone	Sandstone, very fine to medium	
		Sandstone, very fine to fine, silty	
		Sandstone, very fine to medium, some zones of very fine to fine sandstone and siltstone	
		Sandstone, very fine to fine, some thin zones of siltstone and shale	Upper sandstone Gravel Aquifer
	Upper siltstone	Siltstone	Confining bed
	Lower sandstone	Sandstone, very fine to fine, shaly	"Openings" often reported
		Sandstone, very fine to fine	
		Sandstone, very fine to fine, silty, or sandy shale	
		Sandstone, very fine to fine	
	Lower siltstone	Sandstone, very fine to fine, silty, or sandy shale	
Shale	Unit 1	Siltstone	
	Unit 2	Sandstone, very fine to fine, shaly or silty	
		Siltstone	
		Sandstone, very fine to fine, shaly or silty	
Shale	Shale A	Shale	
		Sandstone, very fine to fine, shaly, or sandy shale	
	Shale B	Shale	
		Sandstone, very fine to fine, shaly	

From Granneman and Twenter,
1985.

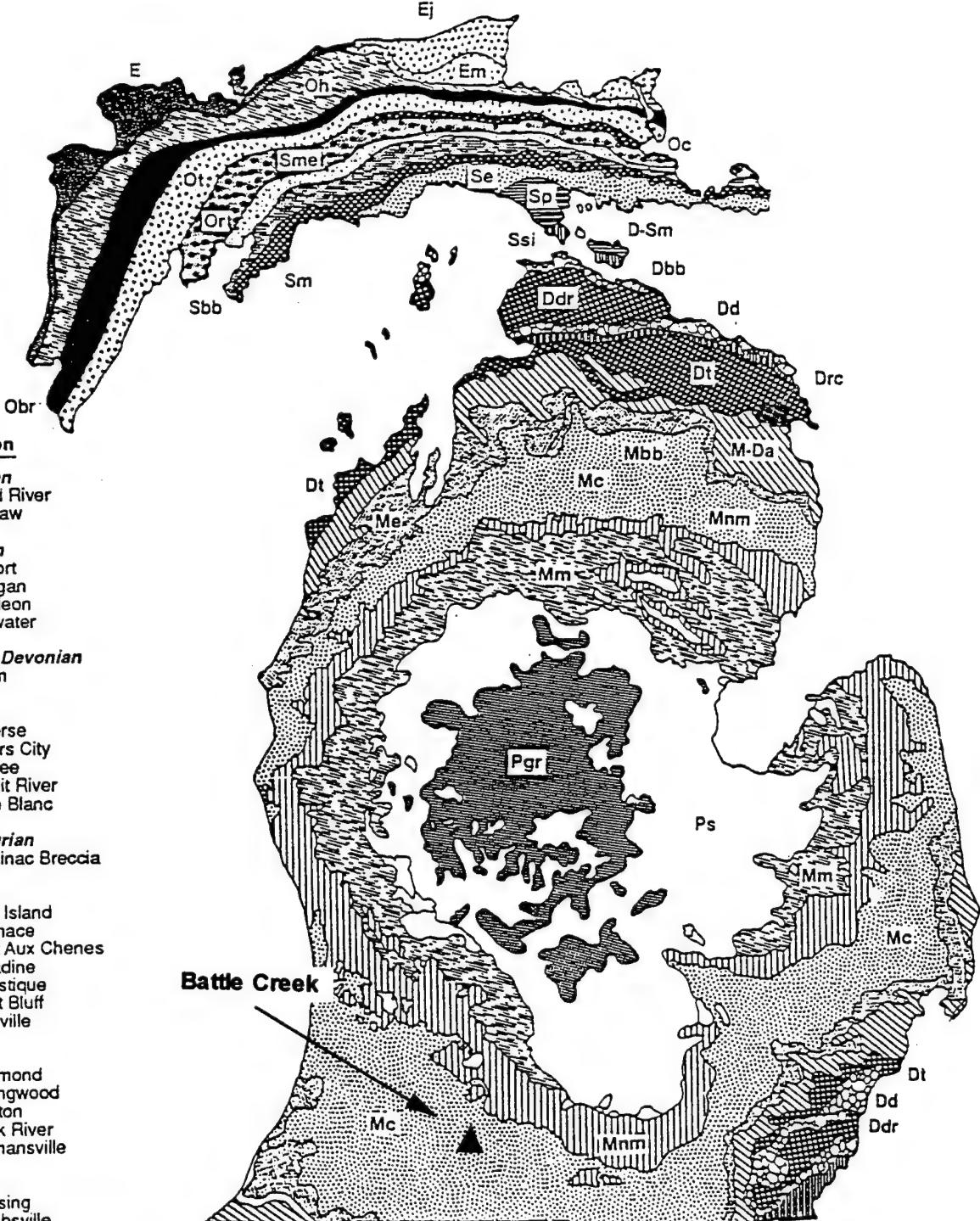
DRAFT

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

TYPICAL LITHOLOGIC COLUMN
IN BATTLE CREEK, MICHIGAN AREA

EARTH TECH

Figure 3-2



DRAFT

APPROXIMATE SCALE 1"=50 MILES

0 25 50 100 150 200 250 MILES

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

BEDROCK GEOLOGY MAP
OF MICHIGAN
EARTH TECH

Figure 3-3

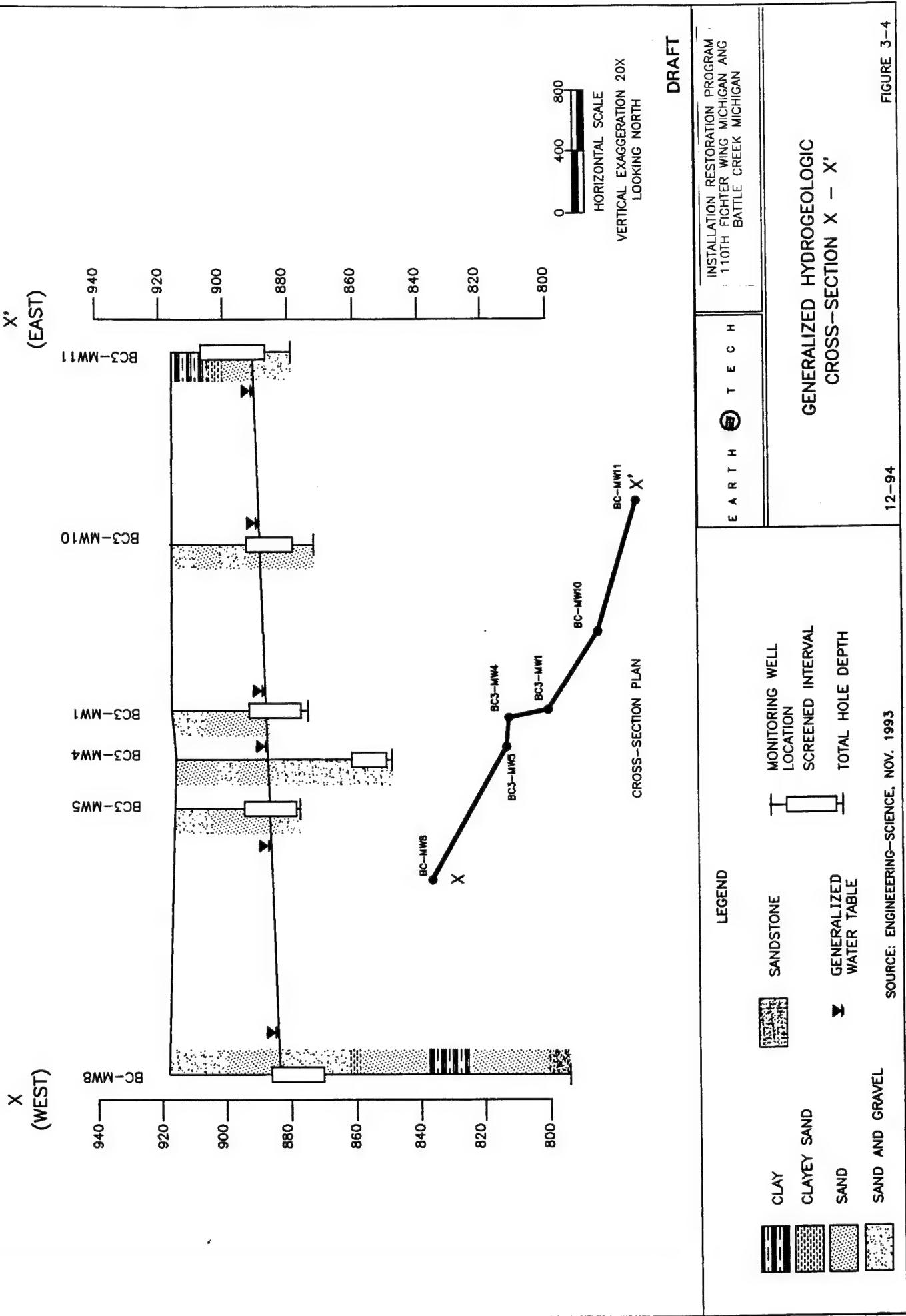
In the Battle Creek area, the Marshall Formation underlies the glacial deposits (Figure 3-2) and ranges in thickness from about 10 to 140 ft. This formation is very fine- to coarse-grained sandstone containing layers of siltstone, shale, and sandy shale (Grannemann and Twenter, 1985). The sandstones can be either hard or soft. The soft sandstones may have been cemented to a lesser degree or have had the cement material weathered away, leaving loose-grained sands. The well cemented or hard sandstones contain fractures and joints. The Marshall Formation overlies the Coldwater Shale which may be up to 1,300 ft thick and contain layers of sandstone, limestone, and cherty limestone (Vanlier, 1966).

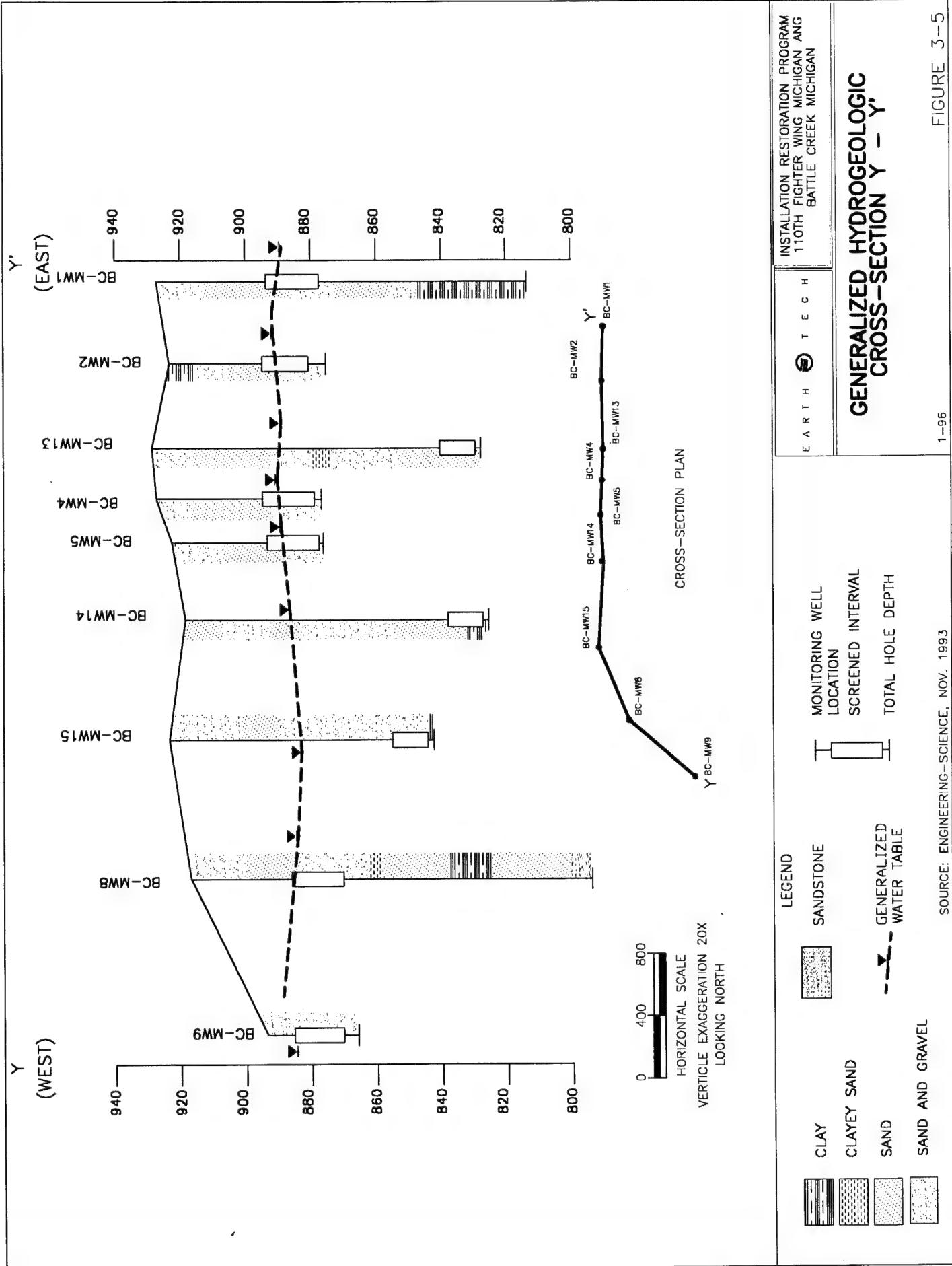
3.4.2 Local Geology

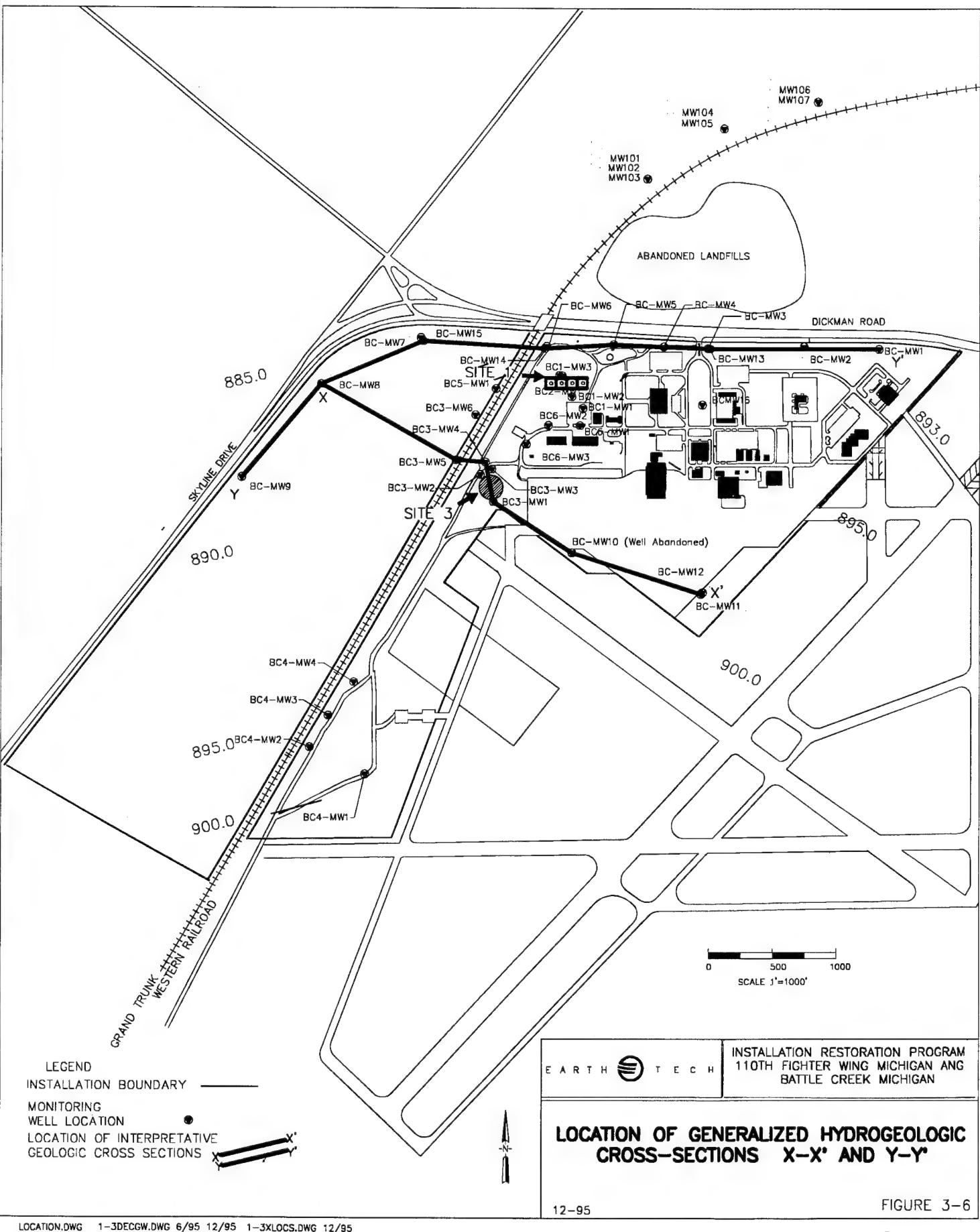
The base is underlain by a mantle of Pleistocene-aged glacial drift material, approximately 100 ft thick overlying the Mississippian-aged Marshall Formation. This drift material consists of layers of sand, sand and gravel, and clay. The stratigraphy of the Pleistocene-aged glacial drift encountered beneath the base is illustrated by two geologic cross-sections labeled X-X' and Y-Y' on Figures 3-4 and 3-5, respectively. Cross-section locations are shown on Figure 3-6. The sands range in size from very fine-grained to very coarse-grained with a predominance of fine- to medium-grained sand. Sand layers are from 10 to 15 ft thick. Beds of sand and gravel are interlayered with the sand layers and are generally 10 to 20 ft thick.

Thin clay layers and silty or sandy clay layers are present in the deeper sections of the glacial drift material. Rock fragments are also common in deeper sections and may be derived from the loosely cemented Marshall Formation.

Gray clay layers, mainly sandy or silty, exist locally at depths of 65 to 115 ft. The clay layers usually directly overlie the Marshall Formation, which is described as a blue, soft, medium-grained, loosely cemented sandstone. The Marshall Formation has an irregular rolling and hilly surface due to preglacial stream erosion.







3.5 HYDROGEOLOGY

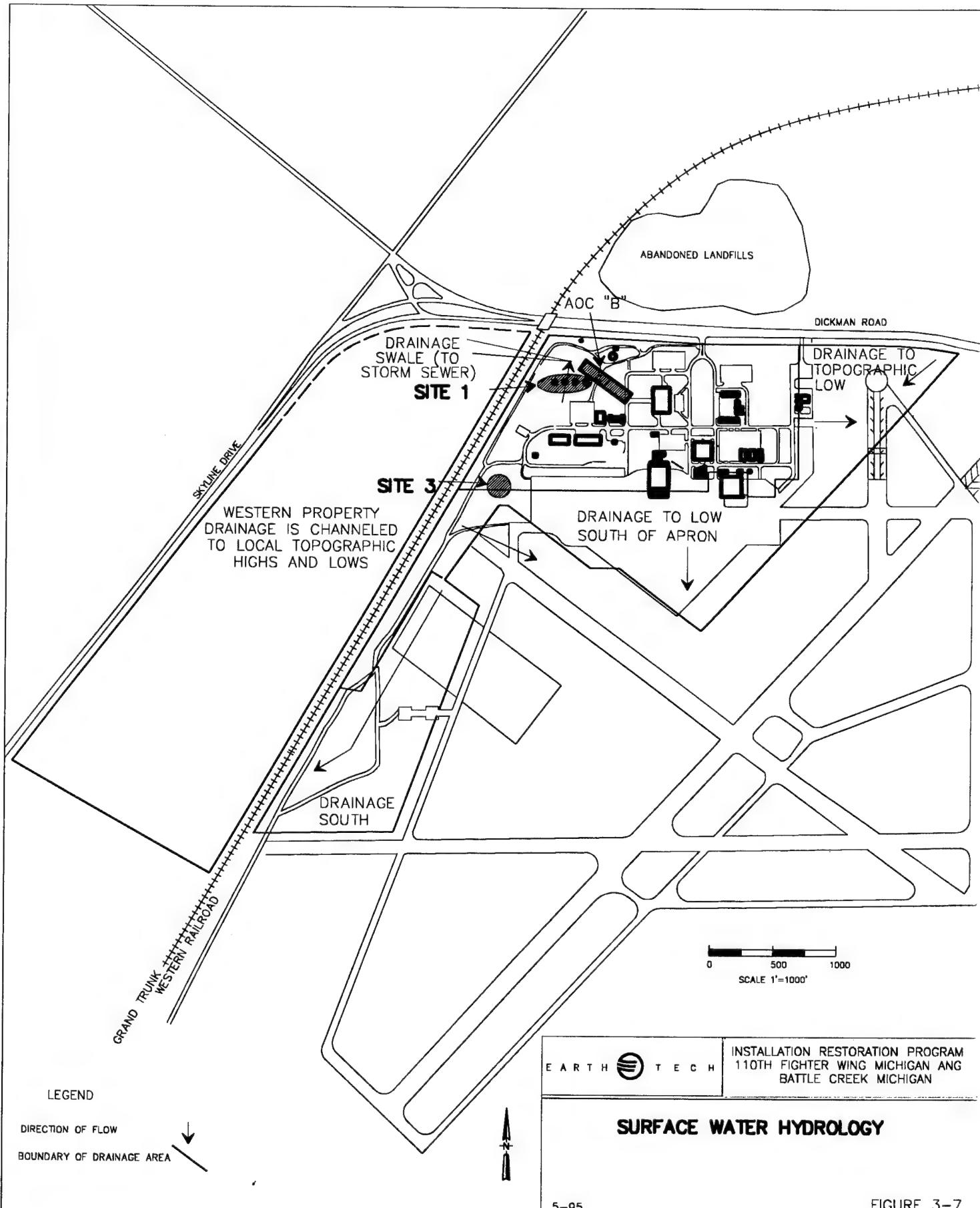
The regional and local hydrogeologic settings will be presented in the following subsections.

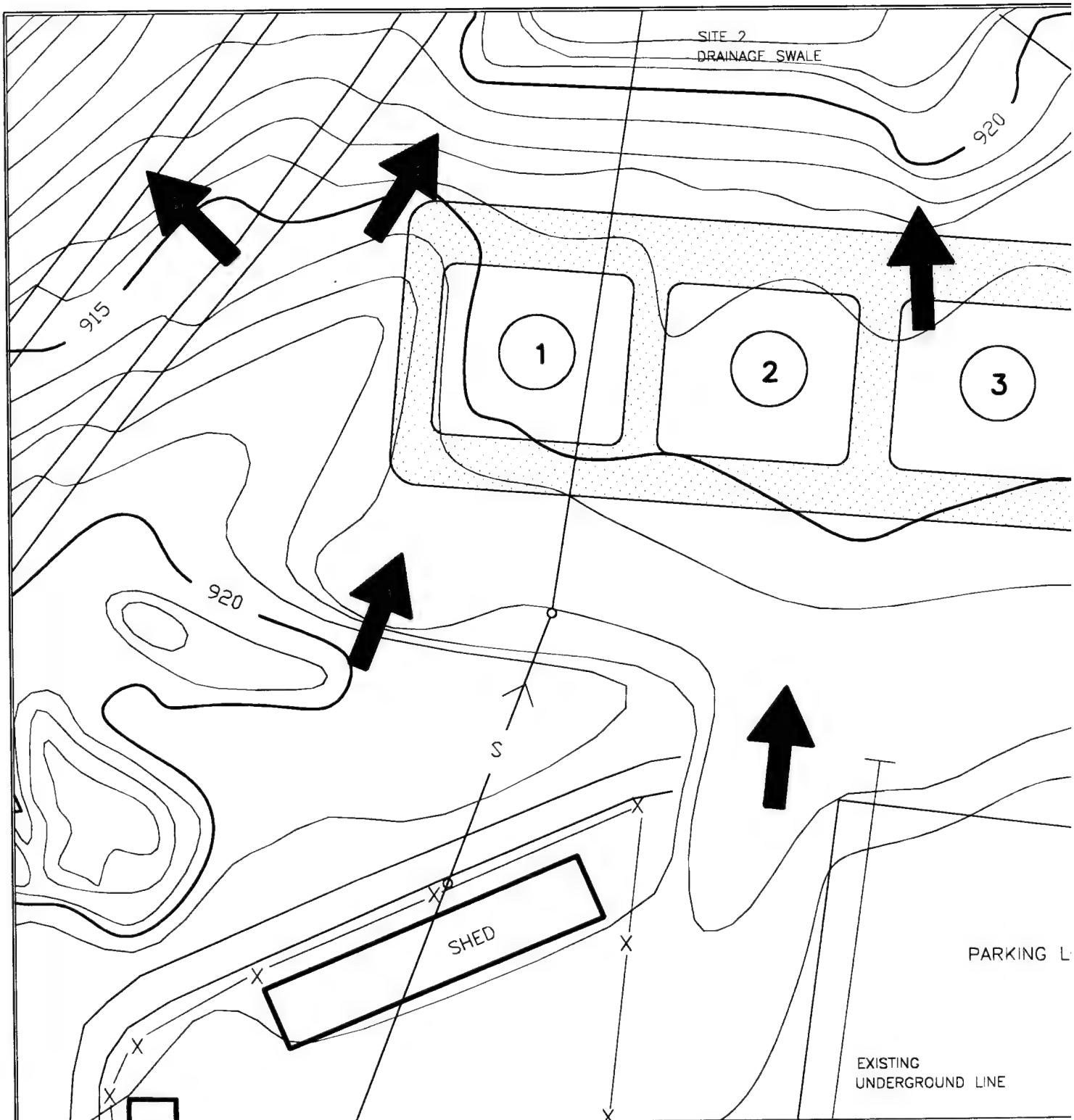
3.5.1 Surface Water

The major surface water features of the area are the Kalamazoo River, Harts Lake, and Goguac Lake. The Kalamazoo River is located approximately 1.5 miles north of the base, Goguac Lake is located approximately 2 miles southeast of the base, and Harts Lake is located approximately 0.5 miles west of the base (Figure 2-1). Approximately one-third of the annual precipitation in the vicinity of the base flows into the Kalamazoo River by direct run-off, or by infiltrating or percolating into the ground and then discharging into the Kalamazoo River by underground flow. The remaining annual precipitation is returned to the atmosphere by transpiration and evaporation from plants (Vanlier, 1966). Localized ponding and wet areas occur throughout the Battle Creek area, but most streams in the area discharge into the Kalamazoo River.

Storm water from the northern half of the base discharges into small streams flowing in a northerly direction and collects in the northern drainage swale. Storm water from the southern half of the installation drains in a southwesterly direction and ultimately discharges into wetlands. The 1986 Base Master Plan, prepared by the ANG, indicates there are no surface streams discharging from these wetlands.

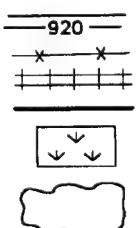
Because of the generally low relief at the base, surface water drainage has been improved by the construction of storm sewers or drainage ditches. Figure 3-7 illustrates the general surface and storm water flow directions on the base. Surface water collected from the main portion of the base drains in a northerly direction to the drainage swale (IRP Site 2). The local surface water drainage proximal to Site 1 is shown on Figure 3-8. Drainage across Site 1 is channeled to the swale through a series of underground storm drains: surface water generated by precipitation falling on Site 1 flows to the north, toward the swale, while the tarmac and portions of the hangar drain in a southerly direction to a low area just off the apron. This area roughly corresponds with the fuels refueling/defueling area ("V" in the apron). There is no surface water outlet from this low area. A third area of the base (by the





LEGEND

T Telephone
 OHU Overhead Utilities
 F Fire Alarm
 C Communication
 SL Sanitary Sewer Line
 S Storm Drains
 G Gas
 W Water



920
 * *
 - - - -
 ▽ ▽
 - - -

3
 310

Above Ground Storage Tank (Pre-existing)
 Building with ID Number
 Roads
 Direction of Overland Surface Water Drainage

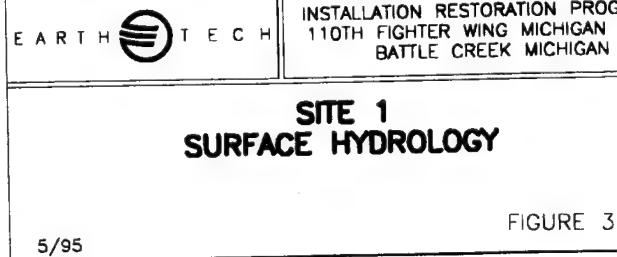
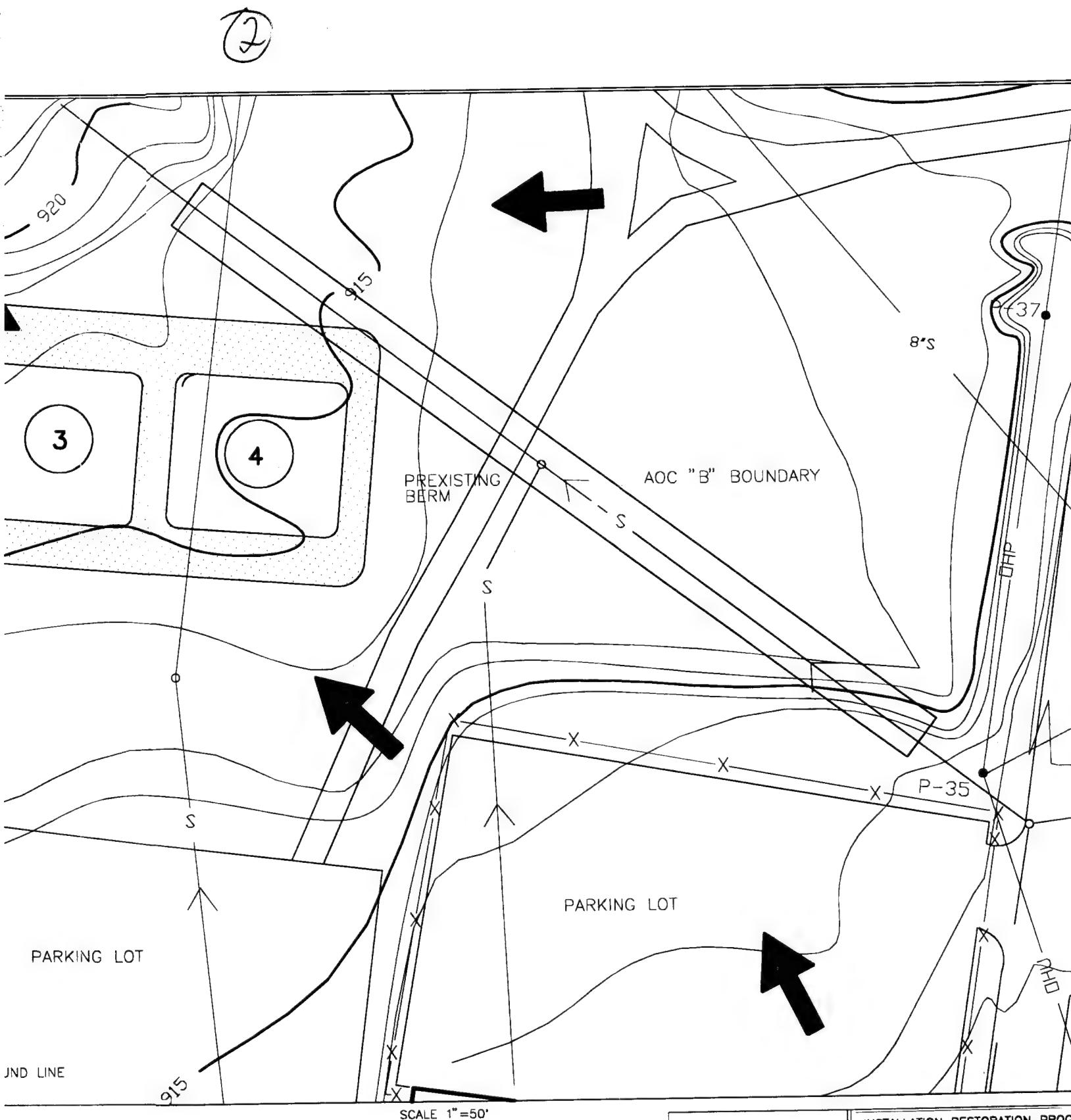
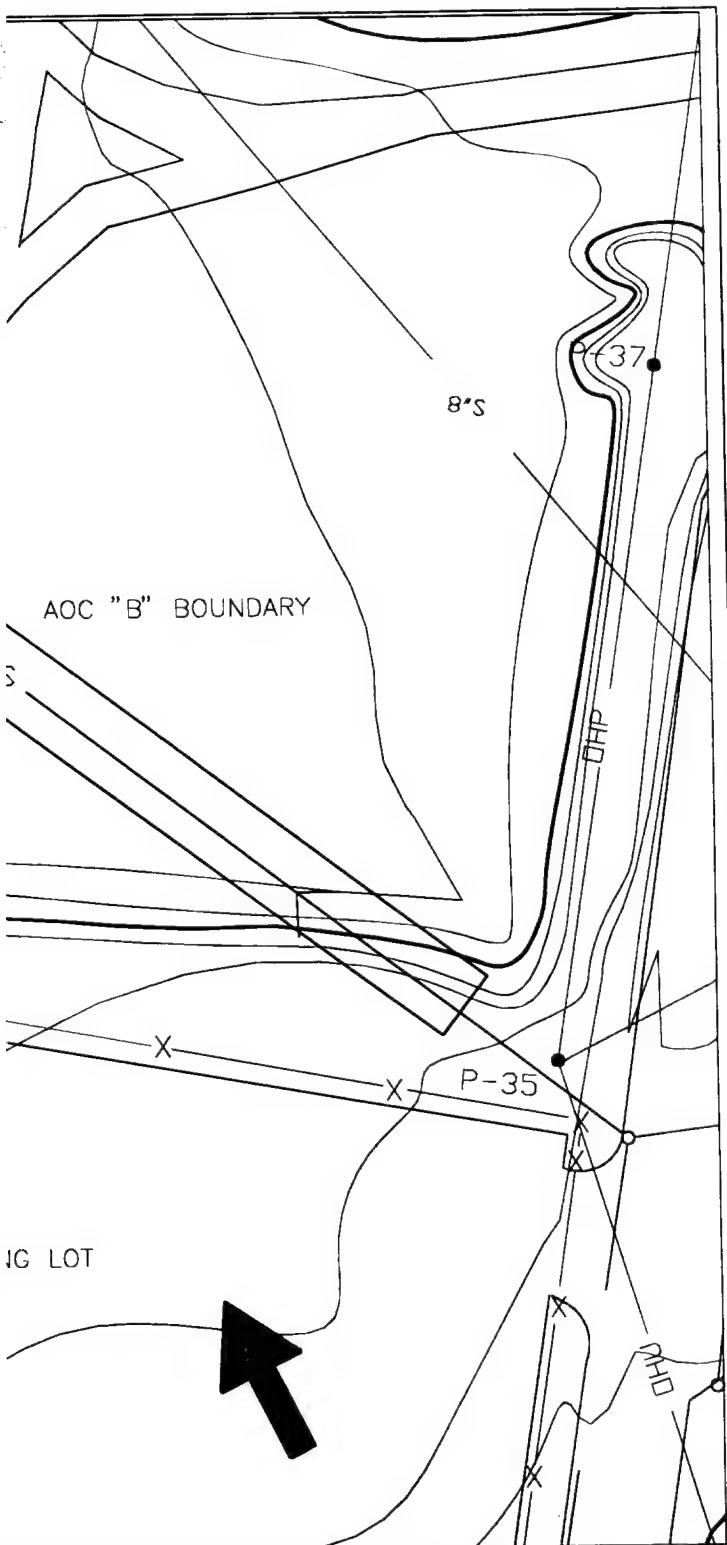


FIGURE 3

(3)



EARTH TECH

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 1
SURFACE HYDROLOGY**

FIGURE 3-8

new POL area) is serviced by a storm sewer system that drains south and west. The outfall from this area goes under the Grand Trunk Western Railroad property and in the future will be the permitted storm sewer outfall.

The base is not within an area classified as a floodplain (Hickock, 1985). According to the Flood Insurance Rate Map (FIRM) for the city of Battle Creek, the W.K. Kellogg Airport, including the base, is in "Zone C", an area of minimal flooding from rivers (Federal Emergency Management Agency, FIRM, 14 April, 1983).

3.5.2 Regional Hydrogeology

Groundwater occurs in useable quantities in both the glacial deposits and the Marshall Formation in the Battle Creek area. These two aquifers are reported to be connected hydrologically, although relatively impermeable clay layers may be present locally in sufficient thickness to retard water movement between the glacial materials and the Marshall Formation. In some areas, the two aquifers function as a single hydrologic unit. Most of the water that enters the glacial aquifer eventually moves to the Marshall Formation and is discharged to stream flow or as well withdrawals (Vanlier, 1966). Although it is generally used only for domestic supplies, the glacial aquifer produces water of sufficient quality and quantity for municipal supplies. The depth to the groundwater in the glacial aquifer varies with topography gradients and surface water flow patterns. The glacial aquifer is recharged directly from precipitation and infiltration. Horizontal conductivities in the glacial aquifer range from 15 to 110 ft per day (Grannemann and Twenter, 1985).

3.5.3 Local Hydrogeology

Groundwater beneath the base occurs in the surficial glacial drift and in the Marshall sandstone under unconfined conditions. The glacial aquifer beneath the base consists of very fine to coarse sand, gravel, silt, and sandy clay. Limited data indicate that the glacial aquifer is approximately 110 to 135 ft thick. Some of these deposits include significant amounts of clay and silt-sized materials which reduce permeability in these areas. However, in other areas, these finer particles have been washed out of the sand and gravel deposits, which increases the permeability of these deposits.

The depth to the water table in the glacial aquifer ranges from approximately 10 to 40 ft below land surface at the base. Groundwater elevations range from approximately 899 ft AMSL at Site 4 to approximately 844 ft AMSL at the northern base boundary. The general groundwater flow direction across the base is to the northwest, although a radial pattern is exhibited at the central portion of the northern base boundary.

The glacial aquifer groundwater level elevations and flow direction beneath the base in March 1991 are shown on Figure 3-9. Recharge to the surficial aquifer is due to infiltration of precipitation and surface water. Movement of water into the Marshall sandstone may be hampered where the glacial drift material has a higher clay content. A thick clay layer is present under portions of the base but is not extensive over the entire area (ES, November 1993). The water table elevations from 1987 to 1989 (ES, November 1993) show a pattern similar to those on Figure 3-9.

A 160 ft deep well set into the Marshall sandstone aquifer supplied the base's water until 1986. Presently, the base uses water supplied by the city of Battle Creek, Michigan. According to CDM (June 1992), the private wells sampled north of Dickman Road that were contaminated are no longer used. The residences served by these wells were supplied with municipal water in 1990.

3.6 GROUNDWATER USE

Water well records were obtained from the Calhoun County Department of Public Health for Township 2 South, Range 8 West, Sections 3, 4, 5, 8, 9, 10, 15, 16, 17, 20, 21, and 22 and for Township 1 South, Range 8 East, Sections 32, 33, and 34. The present use status of these wells is unknown. The wells for which records were obtained from the county are presented on Figure 3-10. As shown on this figure, the nearest wells down-gradient (north) of the base are located in Section 33, Township 1S, Range 8E, approximately 1 mile north of the northern base boundary. According to the water well records there are eight wells located in Section 33. Two of these eight wells are completed in bedrock, while the other six wells are reportedly completed in glacial sands and gravels. As is also shown on Figure 3-8,

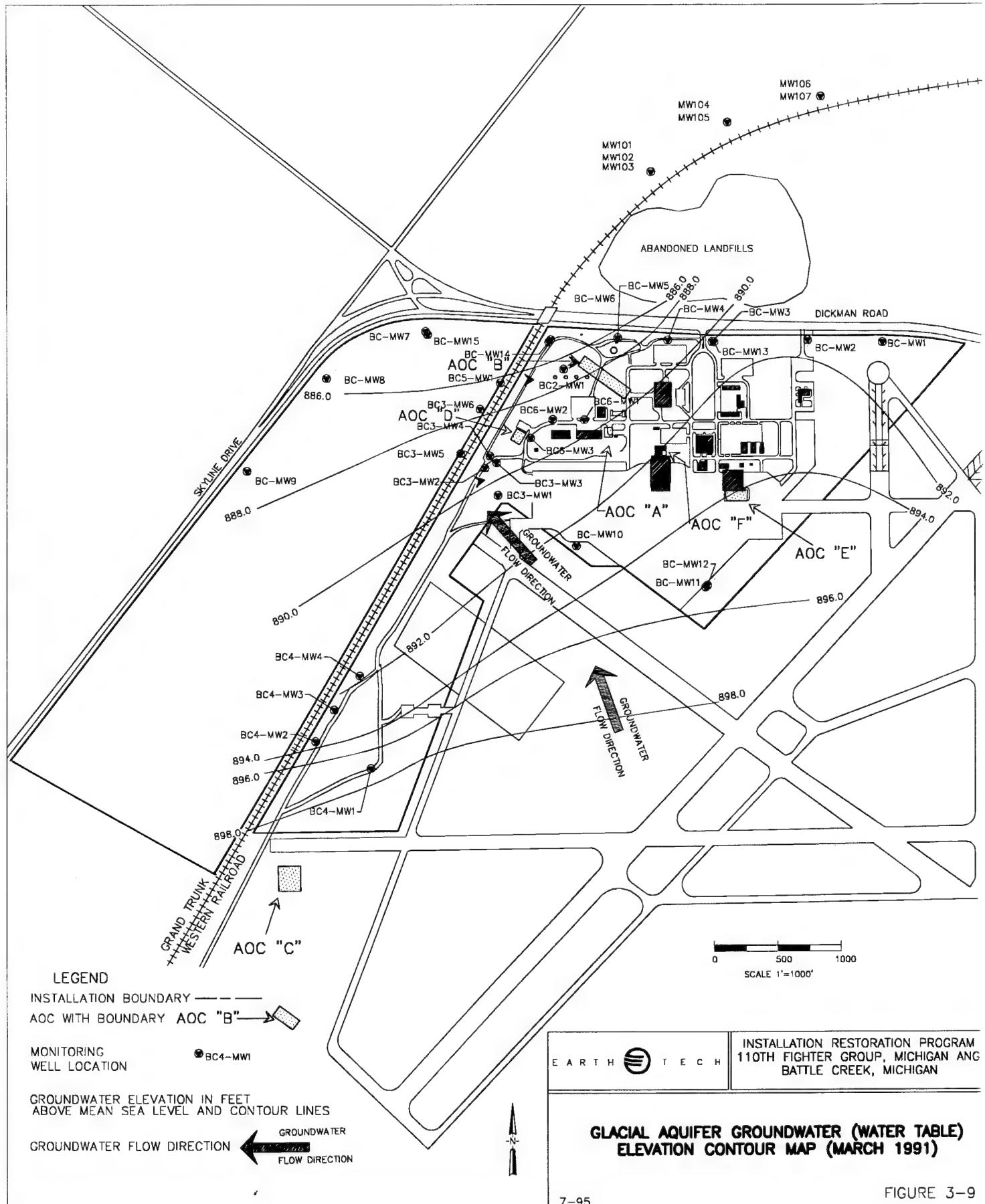
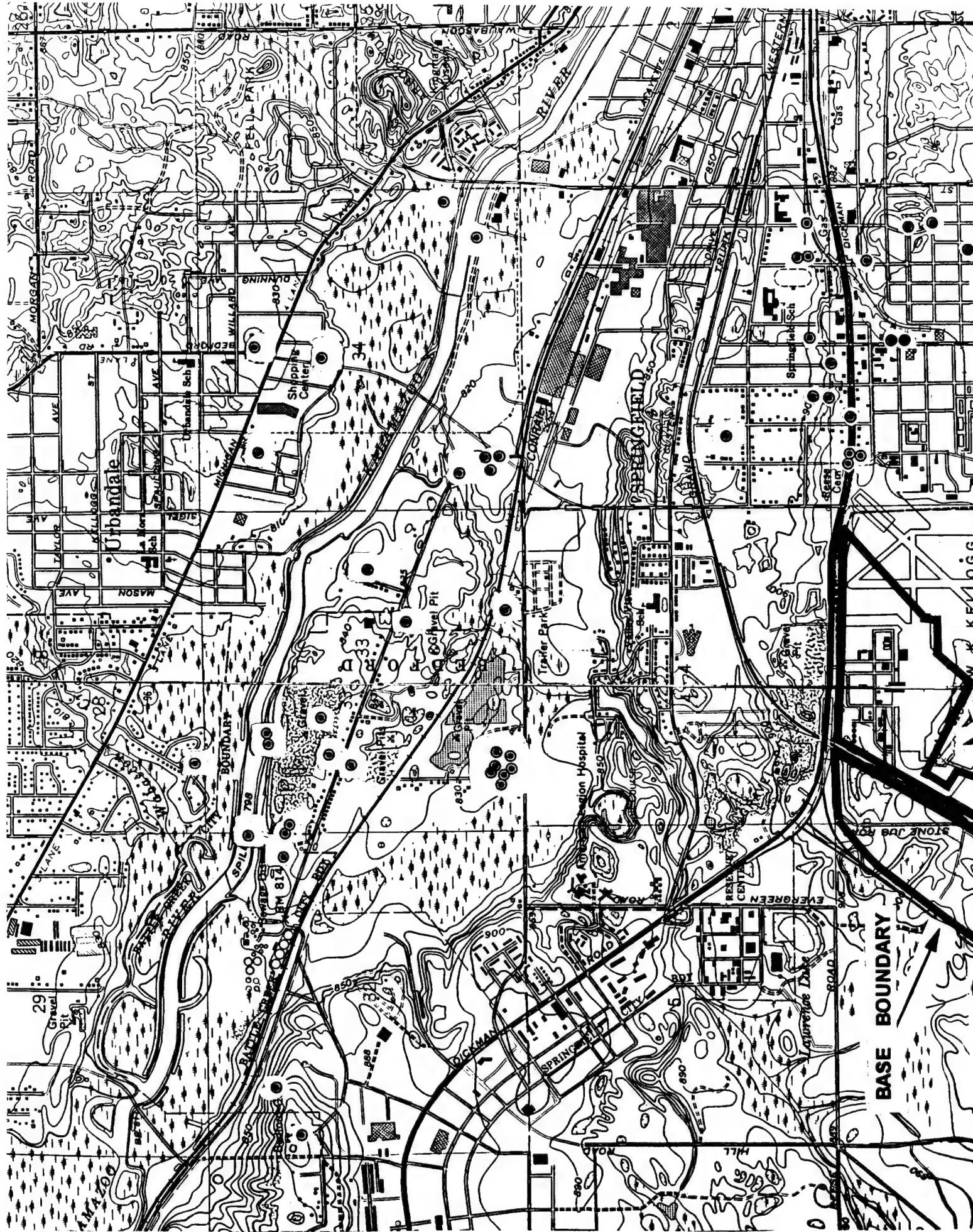
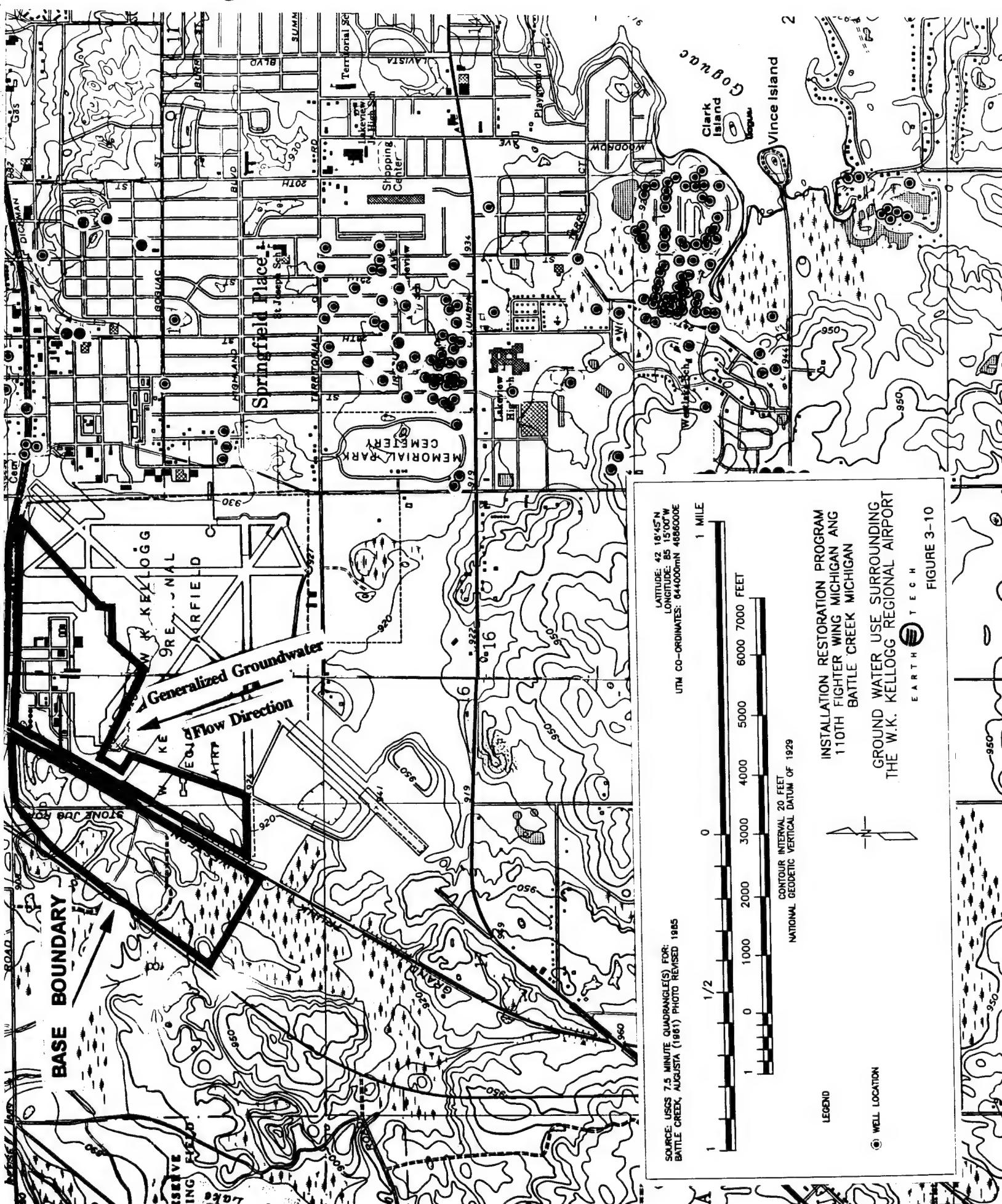


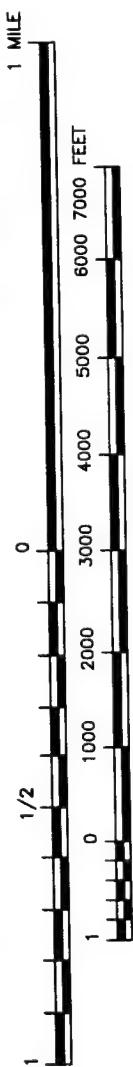
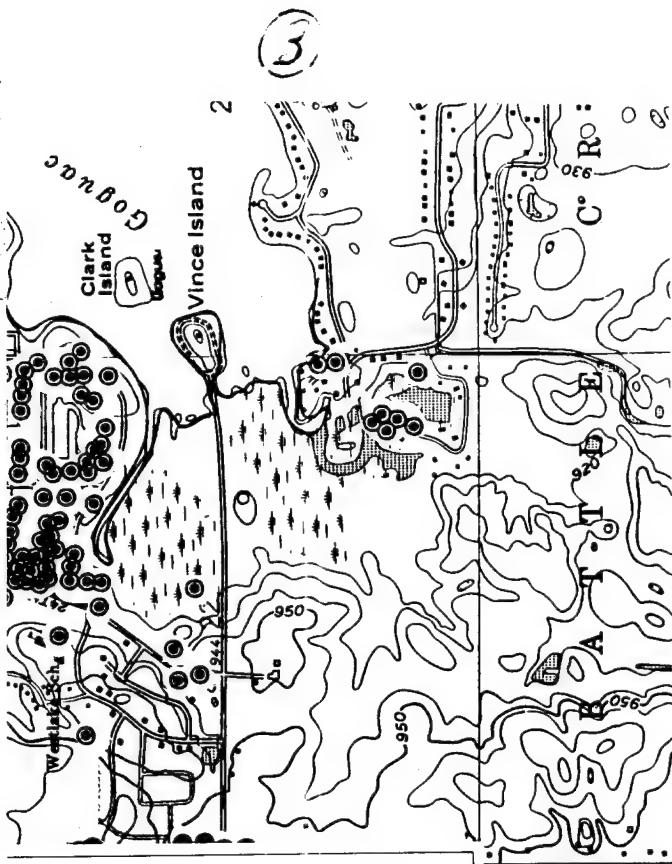
FIGURE 3-9





SOURCE: USGS 7.5 MINUTE QUADRANGLE(S) FOR:
BATTLE CREEK, AUGUSTA (1981) PHOTO REVISED 1985

LATITUDE: $42^{\circ} 19' 22''$
LONGITUDE: $85^{\circ} 15' 00''$ W
UTM CO-ORDINATES: 644000mN 4886000E



NATIONAL GEODETIC VERTICAL DATUM OF 1929

CONTOUR INTERVAL 20 FEET

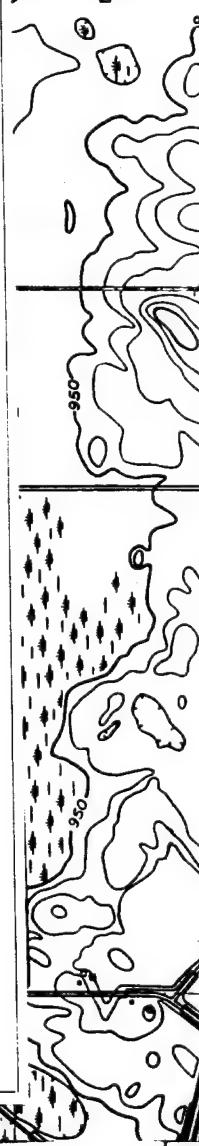
LEGEND

● WELL LOCATION

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN
GROUND WATER USE SURROUNDING
THE W.K. KELLOGG REGIONAL AIRPORT

EARTH TECH

FIGURE 3-10



additional wells exist at a radial distance of 1 to 2 miles north of the base, and to the east and southeast (cross-gradient) of the base.

3.7 CRITICAL HABITATS/ENDANGERED OR THREATENED SPECIES

Critical habitats are specific areas that are recognized or managed by federal, state, and/or local governments and/or private organizations as rare, unique, unusually sensitive, or important natural resources.

While permanent and seasonal habitats of federally designated endangered species, nature preserves such as federal and state parks, wilderness areas, wildlife sanctuaries, and wetlands are included as critical habitats, parks established solely for historic preservation or recreation are not.

According to the Phase I Records Search (HMTc, 1987), no endangered or threatened species of flora or fauna are located in the vicinity of the base. Wetlands exist in the central portion of the area west of the railroad, and in an area which forms the southern base boundary to the west of the railroad. These wetlands, however, are not critical habitats (i.e., unique or unusual natural settings that are necessary for the continued propagation of key species in the ecosystem). No wilderness areas exist within a one mile radius of the base.

More recently, the Michigan Department of Natural Resources (MDNR) has indicated that *Nortropis anogenus* (Pugnose shiner) and *Filipendula rubra* (Queen of the Prairie), which are found in the Battle Creek area, are listed as threatened (Personal communication with Thomas Weise, MDNR, 1994). However, neither of these have been identified in the vicinity of the base.

Based upon the information shown in the United States Geological Survey 7.5-minute series topographic maps of the base and its surrounding areas, no publicly-owned nature preserves or wildlife sanctuaries are present within a three mile radius of the base (Radian, July 1994).

4.0 FIELD PROGRAM

The RI field program that was implemented by EARTH TECH at the 110th FW, MIANG, Battle Creek, Michigan during 1994 and 1995 followed guidelines established by the Draft Final RI WP and Sampling and Analysis Plan (SAP) (EARTH TECH, September 1994) and are described in this section. These activities include screening and confirmation activities. The screening results served as guidance for the confirmation field activities.

4.1 CHRONOLOGY OF ACTIVITIES AND DEVIATIONS FROM THE WORK PLAN

A chronology of the field activities completed during the RI is included in the following subsections. Deviations from the WP and the rationale for each change are included in the following discussions.

May 18, 1994 to May 26, 1994

- Collected and analyzed groundwater samples from wells BC-MW1 through BC-MW15, BC2-MW1, and BC3-MW1 through BC3-MW6.
- Obtained groundwater elevation measurements from the base and the MDNR wells located north of the abandoned landfill.

October 31, 1994 to November 10, 1994

- Collected groundwater screening samples 1GW1 through 1GW12 (excluding 1GW2) using Geoprobe® methods; submitted each sample for VOC and SVOC analyses. FCR #2 was submitted to allow for the collection and analysis of one additional screening sample. This sample was located along the western edge of the asphalt parking lot south of Site 1.

- Advanced three shallow borings at Site 3 and collected surface and subsurface samples for PP metals plus barium. The groundwater screening and soil sampling proposed in the Draft Final WP was not completed because the proposed field efforts would have duplicated fieldwork already completed under the AFCEE bioventing pilot study (FCR #1).
- Advanced 18 soil borings at Site 1. At the time sample 1GW6 was collected, it was suspected that free-phase product existed at this location, although the preliminary soil sampling results did not indicate the existence of a source area at 1GW6. Six borings were sampled at the 10 to 12 ft below ground surface (bgs) interval around groundwater screening sample location 1GW6 to attempt to identify a source area near 1GW6. FCR #2 documents the attempt at source identification around location 1GW6. The remaining 12 borings were sampled at 5 ft intervals and advanced until the water table (or refusal) was reached.

Proposed December 1994 Plan

After the October 31 through November 10, 1994 field effort was completed, additional fieldwork was scheduled during December 1994 to finish the RI. The proposed field events, as described in a memorandum dated December 9, 1994 from EARTH TECH to HAZWRAP, included:

- Installation of one observation piezometer and three monitoring wells at Site 1 and the collection of groundwater samples from the three Site 1 wells.
- Soil sampling from the observation piezometer, from the surface soils at Site 1, and from background locations on-base.
- Geoprobe® groundwater sampling and analysis from three locations up-gradient of well BCMW4.

The December 1994 fieldwork was initiated on December 11, 1994. On December 12, 1994 additional comments regarding the proposed plan (as presented in the Draft Final WP) were received by the project team. Based on the content of the MDNR's comments, the scheduled December field event was modified. The following field activities were completed during December 1994.

December 11, 1994 through December 20, 1994

- Soil sampling from the observation piezometer, from the surface soils at Site 1, and from background locations on-base.
- Geoprobe® groundwater sampling and analysis from six additional locations at Site 1 (FCR #5).
- Installation of one observation piezometer and the installation and sampling of three monitoring wells; two of the wells were installed at Site 1, while the third well was located up-gradient of BC-MW4. The well up-gradient of BC-MW4 was installed to identify an on-base source for the relatively low concentrations of VOCs detected in the base boundary wells. As part of this effort, monitoring well BCMW4 was resampled (FCR #5).

May 17, 1995

- Collected one groundwater sample from well BCI-MW2 (FCR #7).

The remaining FCRs are considered as having only minor impacts on the project and are not discussed further. Technical Records of Project Change (TRPCs) have been submitted for the following major changes:

- The addition of water quality parameters to the May 1994 groundwater sampling event (TRPC #1).
- The completion of background soil sampling (TRPC #2).

- Analysis of PP metals at Site 1, rather than just lead per guidance contained in the Draft Final WP; the additional analyses were added based on comments received from the MDNR (TRPC #3).
- Combine AOC B and Site 1 soils; complete the RI risk assessment for this entire area (TRPC #4).

4.2 SCREENING ACTIVITIES

Screening activities consisted of the sampling and analysis of soil and grab-type groundwater samples. These screening activities were completed according to HAZWRAP QC Level B protocols (DOE/HWP-69/RI, 1990). The screening data are presented in Appendix B. Table 4-1 includes a summary of the screening activities completed during the RI.

4.2.1 Groundwater Screening

Groundwater screening activities were completed at Site 1 to assist the project team in determining the nature and extent of groundwater contamination beneath the site. Groundwater screening results were confirmed by the installation and subsequent sampling of groundwater monitoring wells. A total of 21 groundwater screening samples were collected from Site 1. The samples were analyzed using standard EPA laboratory methods at EARTH TECH's Grand Rapids or Livonia, Michigan laboratories following HAZWRAP QC Level B protocols. Groundwater screening locations are presented and discussed in Section 5.0, Investigation Findings.

4.2.1.1 Sampling Methodology

All groundwater screening samples except for two were collected using a Geoprobe® unit. The remaining two samples were collected from an existing monitoring well (one sample) or through the hollow stem augers on the drilling rig (one sample). Sample collection procedures are described in the following subsections.

**TABLE 4-1 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES
110TH FW, MIANG, Battle Creek, Michigan**

Location	Field Activities		Media Analysis	
	Screening	Confirmation	Water	Soil
Facility Background	<ul style="list-style-type: none"> Advanced 4 shallow borings Analyzed 8 surface soil samples for PAHs (immunoassay) Analyzed 4 subsurface soil samples for PAHs (immunoassay) 	<ul style="list-style-type: none"> Advanced 4 shallow borings Submitted 4 of 8 surface soil samples for analysis Submitted 4 subsurface soils for analysis 	(see base boundary)	<ul style="list-style-type: none"> VOC (SW846 8240) SVOC (CLP SOW) Priority pollutant metals plus barium (SW846)
Site 1 - Fuel Tank Farm	<ul style="list-style-type: none"> Advanced 18 soil borings Collected 87 (including 7 duplicates) soil screening samples for PAH (immunoassay) analysis Collected 37 (including 3 duplicates) soil screening samples for VOC analysis Collected 21 (including 3 duplicates) groundwater samples for VOC, SVOC analyses 	<ul style="list-style-type: none"> Advanced 18 soil borings Submitted 33 samples for confirmation analysis Installed 3 monitoring wells and 1 temporary well Submitted 4 groundwater samples for confirmation analysis 	<ul style="list-style-type: none"> VOCs (SW846 8010/8020) SVOCs (CLP 10/92 SOW) Metals (CLP SOW) 	<ul style="list-style-type: none"> VOC (SW846 8240) SVOC (CLP SOW) Priority pollutant metals plus barium (SW846)
Site 3 - Fire Training Area	None	<ul style="list-style-type: none"> Advanced three shallow borings Submitted three surface soil samples and three subsurface soils for analysis Submitted 6 groundwater samples for analysis 	<ul style="list-style-type: none"> VOCs (SW846 8010/8020) SVOCs (SW846 8270) Metals (CLP SOW) 	<ul style="list-style-type: none"> Priority pollutant metals plus barium (SW846)
Base Boundary Wells	None	<ul style="list-style-type: none"> Submitted 15 groundwater samples for analysis (Round 1) Installed well BC-MW16 Submitted 2 groundwater samples from wells BC-MW4 and BC-MW16 for analysis (Round 2) 	ROUND 1 - May 1994 <ul style="list-style-type: none"> VOCs (SW846 8010/8020) SVOCs (SW846 8270) TAL metals (SW846) Chloride (SW846 - 9251) Nitrate (EPA 353.2) Total dissolved Solids (EPA 160.1) Sulfate (SW846 - 9039) 	None
			ROUND 2 - December 1995 <ul style="list-style-type: none"> VOCs (SW846 8010/8020) SVOCs (CLP 10/92 SOW) TAL metals (CLP SOW) Chloride (SW846 - 9251) Sulfate (SW846 - 9039) 	

CLP - Contract Laboratory Program
EPA - Environmental Protection Agency
PAH - polycyclic aromatic hydrocarbon
SOW - Statement of Work

SVOC - semivolatile organic compound
TAL - Target Analyte List
VOC - volatile organic compound

wpt4-01_1-072-June 10, 1996

Geoprobe Sampling

Prior to collecting each groundwater sample, the tool string of the Geoprobe® unit was fitted with a stainless steel, slotted, lead probe. The slots in the lead probe allowed water to enter the interior of the threaded, 3 ft long, 0.5 in. diameter probe rods. Sampling of the water contained in the rods was accomplished by inserting 0.375 in. polyethylene tubing through the hollow probe rods into the groundwater. The end of the tubing was equipped with a foot or check valve. Water was drawn up into the tubing by applying an up and down motion to the tubing (which allows the foot valve to open and close) or through the use of a peristaltic pump. Three to five probe rod volumes (each 3 ft probe rod contains an approximate volume equal to 0.11 liter of water) were purged from each sampling point prior to the collection of a groundwater sample. Sample collection was completed by manually filling the tubing with water, removing the tubing from the interior of the probe rods and draining the tubing into the appropriate sample containers. The containers were then properly labeled and placed on ice, and COC procedures initiated. The samples remained on ice in the custody of the field team until they were delivered to the laboratory.

Well Sampling

Groundwater samples for screening analysis were also obtained from BC2-MW1. Well sampling procedures followed during the collection of samples for screening analysis are the same as the groundwater sampling procedures described in Section 4.3.3.4.

Temporary Well Sampling

Groundwater sampling was completed from one temporary monitoring well completed at Site 1. A drilling rig was used to advance a string of continuous flight hollow stem augers to a depth approximately 5 ft below the top of the water table. The drilling rig was removed from the hole and the augers were allowed to fill with water. Sampling of the groundwater was accomplished through the augers following the procedures which are described in Section 4.3.3.4.

4.2.1.2 Analytical Methods

Fifteen of the groundwater samples collected during the November and December 1994 field event were analyzed for an abbreviated list of VOCs (EPA SW846 Method 8021) and SVOCs (PAHs only - EPA SW846 Method 8270) at EARTH TECH's Grand Rapids, Michigan analytical laboratory. Of these 15 samples, sample 1GW4, due to poor sample volume recovery, was analyzed for VOCs only. The compound lists and reporting limits for these screening methods are presented in Table 4-2. The remaining six samples were analyzed for a more complete list of VOCs (EPA SW846 Method 8260) and SVOCs (EPA SW846 Method 8270). The compound lists and reporting limits for these samples are presented on the laboratory analytical sheets included in Appendix B.

4.2.2 Soil Screening

Soil screening activities completed during the RI consisted of analyses for eight VOCs (EPA SW846 Method 8021) and for PAHs by immunoassay testing. Initially, samples were analyzed under both screening methods.

Gas chromatograph (GC) analysis for VOCs was discontinued after 37 samples were run, because the hydrocarbons found in the soils, which had reportedly originated from heating oil, were dominated by late-eluting compounds. The presence of these late-eluting compounds required several additional blank analyses, per sample, be run in order to clean the GC column. The additional blank analyses slowed down the entire process, thereby rendering GC analysis ineffective as a real-time screening technique. The compound list and reporting limits for the VOC soil screening are also presented in Table 4-2. Ninety-two samples (excluding duplicates) were analyzed for PAHs using immunoassay techniques. These soils were analyzed using test kits manufactured by Ohmicron Corporation. The tests were performed following the manufacturer's instructions.

Table 4-2 Target Compounds, ARARs, and MDLs for Field Screening (Groundwater)
110th FW, MIANG, Battle Creek, Michigan

Groundwater Screening	Health-based Drinking Water ARAR ^{(a)(b)}	Selected Screening MDL ^(a)
VOCs		
Benzene	1.2	1
Toluene	1,500	1
Ethylbenzene	74	1
Xylene (total)	13,000	1
Trichloroethene	2.2	1
Tetrachloroethene	0.7	1
Cis 1,2-Dichloroethene	77	1
trans 1,2-Dichloroethene	120	1
SVOCs		
Acenaphthene	1,200	5
Acenaphthylene	25	5
Anthracene	7,000	5
Benzo (a) Anthracene	0.049 ^(c)	5
Benzo (b&k) Fluoranthene	0.049 ^(c)	5
Benzo (a) Pyrene	0.049 ^(c)	5
Benzo (g,h,i) Perylene	25	5
Chrysene	4.9 ^(c)	5
Dibenzo (a,h) Anthracene	0.0049 ^(c)	5
Fluoranthene	840	5
Fluorene	840	5
Indeno (1,2,3-cd) pyrene	0.049 ^(c)	5
2-Methylnaphthalene	11	5
Naphthalene	250	5
Phenanthrene	25	5
Pyrene	520	5

^(a)Units are in parts per billion. These MDLs may not be achievable in all cases.

^(b)All ARARs are MDNR Act 307 Type B criteria.

^(c)Method detection limit can be substituted for the ARAR per MDNR guidance (MERA Operation Memorandum #8, June 21, 1994).

4.3 CONFIRMATION ACTIVITIES

Confirmation activities conducted during the RI include the collection and Level C laboratory analyses of soil and groundwater samples. Compuchem Laboratories, Inc. of Research Triangle Park, Chapel Hill, North Carolina and EARTH TECH Laboratory Services, Grand Rapids, Michigan performed confirmation analytical activities. A majority of the confirmation samples were analyzed under HAZWRAP Level C protocol. Soil samples were collected from confirmation soil borings and hand augered locations, and groundwater samples were collected from monitoring wells. Stearns Drilling of Dutton, Michigan performed drilling activities. The analytical methods utilized to complete confirmation analyses of soil and groundwater samples are included in Table 4-1, which also contains a summary of the entire confirmation program completed during the RI. Details pertaining to sample handling, sample designation and documentation, and field QC sampling are discussed in Section 3.0 of the Draft Final RI SAP (EARTH TECH, September 1994).

4.3.1 Soil Sampling

Confirmation soil sampling was completed to:

- determine the facility background metals concentrations and
- characterize the nature and extent of contamination at Sites 1 and 3.

A total of 98 samples (12 for background, 80 at Site 1, and 6 for Site 3) were collected during the RI. Of these 98 samples, 47 were submitted for confirmation analysis. Sample collection methods are described in the following subsections.

4.3.1.1 Hand Auger Sampling

A total of 26 soil samples were collected for screening and/or confirmation analyses during the RI using a hand auger. Hand augered surface soil samples were collected by initially removing the first one to two inches of grass and gravel from the sample location by using a stainless steel scoop. A hand auger with two, 4 in. long stainless steel sleeves was turned

and pushed approximately one foot into the soil. The auger was then pulled up and laid on plastic. The end of the sample was immediately screened with a photoionization detector (PID) and the results were recorded along with a lithological description and sample location. The ends of one of the sleeves were covered with Teflon® tape and secured with plastic end caps. The remaining sample was placed in a stainless steel bowl and composited using a stainless steel knife. Portions of this composited sample were submitted for screening analysis (PAHs) and confirmation SVOC and metals analyses. The sample was properly labeled and placed in a cooler with ice for sample preservation. Soil samples that were collected using a hand auger were recorded on sampling forms and are presented in Appendix C.

4.3.1.2 Geoprobe® Sampling

A total of 54 soil samples were collected for screening and/or confirmation analyses during the RI utilizing a Geoprobe® unit. These samples were collected using a 24 in. by 1.375 in. outside diameter piston-type sampling barrel fitted with removable stainless steel liners. Each stainless steel liner consisted of four, 6 in. sections kept in line with a polyvinyl chloride (PVC) sleeve. This configuration is capable, depending upon subsurface conditions, of recovering a core approximately 22 in. long by 1-1/16 in. diameter (320 ml). The assembled sampler was attached to the probing rods and driven and/or pushed to the top of the desired sampling depth. The piston stop pin was removed at this time, and the sampler was driven and/or pushed to the end of the sampling interval. The probe rods were then retracted, and the sampler was recovered. Each sampler was disassembled upon recovery, and the stainless steel sample liners removed. The liners were then split apart by hand or with a stainless steel knife. The end of each liner was scanned with a PID meter and the reading was recorded on the boring log. The lead liner was sealed with Teflon® tape and tightly fitting plastic caps for laboratory analysis (VOCs). The remaining sample was extracted and, after a brief examination of the sample, composited (using the same protocols as the hand augered samples). Each sample container was properly labeled and placed in a cooler with ice for sample preservation. Pertinent information such as sampling interval, sample recovery, PID readings, and lithology were recorded. Borehole logs are presented in Appendix D.

4.3.1.3 Soil Analysis

Confirmation laboratory analyses for soil samples included the following: VOCs, SVOCs, and metals (PP and barium). Soil samples were analyzed for VOCs according to EPA SW-846 Method 8240 (EPA, 1986), SVOCs according to EPA SW-846 Method 8270, and metals according to SW-846 Methods. Sampling and analyses were conducted according to HAZWRAP QC Level C guidelines. QA/QC evaluation and laboratory data and validation summaries are presented in Appendix E and F, respectively. A summary of the analytical program is presented in Table 4-3.

Established sample COC procedures were followed during these sampling activities. Field data sheets, COC records (presented in Appendix G), and analytical request forms were completed by the appropriate sampling and laboratory personnel for each sample. Custody seals were used to seal the coolers when samples were shipped to the laboratory to ensure that no sample violations occurred during transportation. HAZWRAP specifications for shipping and packing requirements (DOE/HWP-69/R1) as described in the Draft Final RI SAP (EARTH TECH, September 1994) were followed.

4.3.2 Monitoring Wells

A total of four permanent monitoring wells were installed at the base. Monitoring wells were installed in order to aide in the determination of groundwater flow and gradient and in the determination of the vertical and horizontal extent of contamination in the groundwater.

4.3.3.1 Monitoring Well Drilling

Two of the four monitoring well locations were sampled during drilling. Monitoring well location BC1-MW1 was continuously cored for lithological descriptions to the total depth of the borehole. Soil samples were collected from well BC1-MW2 at four subsurface intervals. Samples were collected in 2 in. inner diameter (ID), 2 and 5 ft long decontaminated, split-spoon core barrels. The split spoons were driven into the soils utilizing a 140 pound hammer. Upon retrieval of the sample, the ends of the split-spoon sample were screened with a field PID in order to obtain information on possible occurrences of contamination.

Table 4-3 Summary of Analytical Program
110th FW, MIANG, Battle Creek, Michigan

Sample Type	VOC ¹	SVOC CLP 3/90 ²	Metals CLP 3/90	Water Quality Parameters ³
Confirmation Analyses				
Soil	36	40	46	
Water	26	26	26	14
Total	62	66	72	14
QA/QC Analyses				
Soil Duplicates	4	4	5	
Water Duplicates	4	4	4	2
Equipment Rinseates	9	9	9	9
Field Blanks	6	6	6	6
Trip Blanks	7			

¹Soils analyzed using SW-846 Method 8240; waters were analyzed using SW-846 Method 8010/8020.

²One water sample delivery group analyzed by CLP 10/92.

³Nitrate, chloride, sulfate, and total dissolved solids (EPA 600/4-79-020, March 1983).

Information pertaining to the drilling of monitoring wells, i.e., sampling interval, blow counts, lithological sample recovery, PID readings, and lithology was recorded on borehole logs which are presented in Appendix D.

4.3.3.2 Monitoring Well Installation and Completion

Upon the completion of the monitoring well boring, monitoring well installation began. The use of continuous flight hollow stem augers for drilling helped maintain the integrity of the borehole. Monitoring wells were constructed of 2 in. ID threaded Schedule 40 PVC casing and either 5 or 10 ft of screen with 0.01 in. slot size. Ten feet of screen was used for water table wells with 5 ft of screen placed in the water table and 5 ft out. The deeper well (BC1-MW3) was constructed with 5 ft of screen at the 40 to 45 ft bgs interval. The augers were pulled in 5 ft increments and the sand filter pack was gradually added to the annulus. Placement of the filter pack through the hollow stem augers in this manner assists in evenly distributing the filter pack around the well screen. Sand was added to each well to a height approximately two feet above the top of the screened interval. After installation of the filter pack, approximately 2 ft of bentonite pellets were placed through the augers into the well. Approximately, 5 gallons of potable water was added, and the pellets were allowed to hydrate for 30 minutes. The remainder of the borehole was completed by backfilling the borehole with

cement-bentonite grout from above the top of the bentonite seal to approximately 2 to 5 ft bgs. The grout was pumped through the augers into each wells' annular space; an auger flight was then removed and the process was repeated until each wells' annular space was full of grout.

All monitoring wells were completed aboveground (stick-up) or flush-mounted at the surface, and the PVC casing was equipped with an air-tight cap. Stick-up steel protective casings and flush-mounts with lids and locks were installed within 2 ft by 2 ft, 6 in. thick concrete pads. Measurements were collected with a stainless steel tape during installation of the sand pack to determine the distribution of filter pack around the well screen. A minimum of three guard posts were installed at stick-up locations in heavy traffic areas and were filled with concrete for stability. Monitoring well construction logs are presented in Appendix H.

4.3.3.3 Monitoring Well Development and Measuring

Following construction, monitoring wells were developed by bailing. Each well was developed until the water was visibly free of settleable solids. Development of monitoring wells flushed out any borehole smear occurring during drilling activities that might obstruct recharge of the sand filter pack. Development allowed the natural formation around the sand filter pack to maximize the amount of water produced in the well. During development procedures, parameters including temperature, pH and conductivity were taken using a Hydac instrument (MN 301353) and were recorded in the field logbook and on purge/sampling forms presented in Appendix I. The water removed from the monitoring wells was containerized for subsequent characterization as discussed in Section 4.5, Investigation Derived Waste Disposition.

Following development, the static water level in each monitoring well was allowed to equilibrate for a minimum of 24 hours before water level measurements were taken and recorded. Groundwater readings were measured to the nearest 0.01 ft and referenced to below top of casing (BTOC). Top of casing elevations, ground elevations and horizontal coordinates were determined by a professional, licensed surveyor as discussed in Section 4.4, Surveying. Potentiometric surfaces were further defined to determine the up-gradient

groundwater flow direction for the IRP sites. Groundwater elevation measurements completed during the field events are also included in Appendix I.

4.3.3.4 Monitoring Well Sampling

A total of 27 groundwater samples (21 samples during May 1994, 5 during December 1994, and 1 in May 1995) were collected and submitted for confirmation laboratory analysis to determine the absence or presence of groundwater contamination. The samples were collected after the monitoring wells were purged. Purging of the monitoring wells consisted of the removal of three to five well volumes using a disposable bailer. While purging, parameters including temperature, pH, and conductivity were taken using a Hydac instrument (MN 301353) and were recorded in the field logbook and on purge/sampling forms, presented in Appendix I.

Water levels were allowed to return to within 90% of static prior to groundwater sampling. Groundwater sampling typically occurred within three hours of the completion of monitoring well purging. Groundwater samples were collected using disposable Teflon® bailers instead of re-usable Teflon® bailers. FCR #3 dated November 4, 1994, was completed in the field and is presented in Appendix A. Filtered metals were collected by attaching a 0.45 micron filter to the bottom of the bailer and utilizing a peristaltic pump to draw the water from the bailer through the filter and into the sample bottle, instead of utilizing a hand pump to pressurize a Teflon® bailer as outlined in the WP (EARTH TECH, September 1994). The samples were properly labeled and placed in a cooler with ice for sample preservation. Details pertaining to sample handling, sample designation and documentation, and sample container and preservation are discussed in sections of the Draft Final RI SAP (EARTH TECH, September 1994).

4.3.3.5 Groundwater Analysis

Confirmation laboratory analyses for groundwater samples included the following: VOCs, SVOCs, and metals (PP and barium). Groundwater samples were analyzed according to methods noted in Table 4-3, Summary of Analytical Program, and are discussed below. Groundwater samples were analyzed for VOCs according to EPA SW-846 Methods 8010 and

8020 (EPA, 1986), SVOCs according to EPA SW-846 Method 8270 or Contract Laboratory Program (CLP) 10/92 Statement of Work (SOW), and dissolved metals according to EPA SW-846 methods (May 1994) and CLP 3/90 SOW (December 1994). Sampling and analyses were conducted according to HAZWRAP QC Level C guidelines. QA/QC evaluation and laboratory data and validation summaries are presented in Appendix E and F, respectively.

Established sample COC procedures were followed during these sampling activities. Field data sheets, COC records, and analytical request forms were completed by the appropriate sampling and laboratory personnel for each sample. Custody seals were used to seal the coolers when samples were shipped to the laboratory to ensure that no sample violations occurred during transportation. HAZWRAP specifications for shipping and packing requirements (DOE/HWP-69/R1) as described in the Draft Final RI SAP (EARTH TECH, September 1994) were followed.

4.4 SURVEYING

EARTH TECH personnel from Grand Rapids, Michigan surveyed the boring and monitoring well locations. Elevations, including the ground surface for all locations and top of casing for all monitoring wells were measured in feet AMSL using a United States Geological Survey benchmark as a reference. Horizontal locations were established using Michigan State Plane Coordinates and reference from a building located at the base. Copies of the surveying reports are presented in Appendix J.

4.5 INVESTIGATION DERIVED WASTE DISPOSITION

Guidance for handling the investigation derived waste (purge and decontamination water, soil cuttings, and miscellaneous solid waste), was detailed in Section 2.5 of the Draft Final RI WP (EARTH TECH, September 1994). Miscellaneous solid waste such as used gloves, aluminum foil, plastic, etc., was disposed of on-base, as trash. Decontamination and purge water was containerized in large capacity polyethylene tanks. Composite samples of this wastewater were collected and analyzed for VOCs, SVOCs, and metals in July 1994, after the completion

of the May 1994 groundwater sampling event and the PA/Site Inspection fieldwork. Wastewater was sampled again after completion of the December 1994 fieldwork. EARTH TECH transmitted the analytical results of the wastewater sampling to the 110th FG Environmental Coordinator August 23, 1994 and March 14, 1995. Copies of these transmittals, including the analytical data, are included in Appendix K. Unused soil samples which were collected during the Geoprobe® soil sampling were returned to the boreholes from which they were obtained. After the soils were returned to their originating borehole, the remaining open space in each borehole was then filled to the ground surface with granular bentonite. Guidance on how to handle the generation of drill cuttings was not contained in the Draft Final WP. Prior to initiating the drilling activities, Ms. Lori Aronoff, Environmental Quality Analyst, Environmental Response Division, MDNR, was consulted on the appropriate way to handle drill cuttings. Soil cuttings generated during the drilling of the Site 1 and base-wide monitoring wells were either placed on, and covered with plastic (if free of hydrocarbons by PID scan), and left next to the borehole from which they originated, or were drummed and left on-site (if suspected of containing hydrocarbons by PID scan). Ms. Aronoff was contacted again on February 22, 1995, to provide further guidance regarding the disposition of these cuttings. Descriptions of these conversations and the analytical results obtained from the soil or groundwater sampling pertinent to each individual borehole was transmitted by EARTH TECH to the 110th FG Environmental Coordinator on March 21, 1995. Copies of this correspondence is also included in Appendix K.

5.0 INVESTIGATION FINDINGS

The results of the RI program completed at the base are discussed in this section. The remaining sections will present the data generated by the RI field and analytical program, including a discussion of the findings for each site. Each site section will address such topics as: sampling locations; analytical results of the screening and confirmational sampling activities; findings relating to geologic and hydrogeologic conditions; comparison of metals concentrations to background; and identification of data gaps. Although applicable chemical-specific ARARs (i.e., NREPA PA 451) are listed in the data tables included in this report, the analytical results for organic compounds in the soils will not be directly compared to the chemical-specific ARARs in the following discussions. For soil inorganic analytical results, descriptions will be limited to those results relative to background concentrations. The significance of these results will be covered in Section 7.0. Organic concentrations in the groundwater samples will be directly compared to the health-based chemical-specific ARARs listed under NREPA PA 451 as a way to prioritize the groundwater analytical data during the discussions presented in Section 5.0. The significance of these results will be covered in Section 7.0.

The interpretations presented in this section are based upon data collected during this investigation and previous investigations, where applicable. The data tables included in this section present only those compounds and analytes for which a positive result was reported in at least one sample. The complete listing of the analytical results is contained in Appendix F.

5.1 BACKGROUND SAMPLING

The field activities completed to determine the background conditions in the soils and groundwater at the base are presented in the following subsections.

5.1.1 Soils

The collection of background soil samples was not proposed in the Draft Final WP (EARTH TECH, September 1994). However, based upon a review of the soil analytical results obtained during the PA/Site Inspection (EARTH TECH, August 1995), which showed metals concentrations elevated above the MDNR default soil background concentrations (Type A), it was recommended that site-specific background metals concentrations be determined. Background surface (less than 1 ft bgs) and subsurface (5 to 7 ft bgs) soil samples were collected from four borings located in the main base area (north and east of the majority of base activities) and at the very southwestern edge of the base (Figure 5-1). The soil samples were analyzed for VOCs, SVOCs, and PP metals plus barium. These data were compiled and background concentrations for PP metals and barium were calculated for surface and subsurface soils following guidance presented in the Verification of Soil Remediation Guidance Document (MDNR, Environmental Response Division, April 1994, Revision 1). The results of this sampling and the calculated background concentrations are discussed in the following subsections.

5.1.1.1 Surface Soil

The analytical results from surface soil background sampling are presented in Table 5-1. Each of the surface soil samples was described as orange brown to dark brown sandy loam topsoil. These samples are considered compositionally representative of the base surface soils.

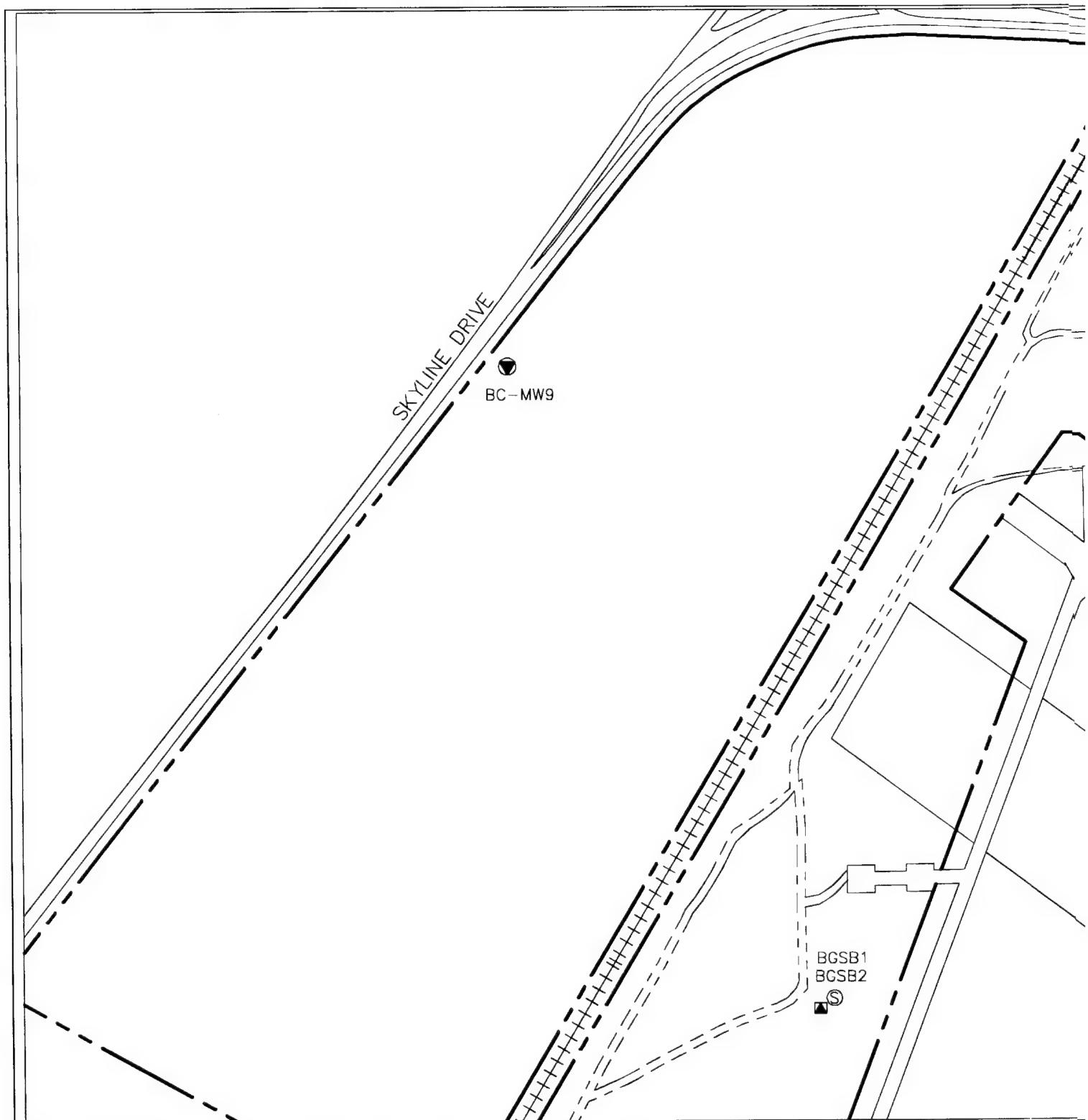
VOCs

No VOCs were detected in the background surface soil samples.

SVOCs

Carbazole, dibenzofuran, di-n-butyl phthalate and seventeen individual PAHs were detected in the background surface soil samples. Excluding di-n-butyl phthalate, surface soil samples from locations BGSB1 and BGSB2 were free of SVOCs. Samples collected from locations

①



LEGEND

— Base Boundary
— Roads

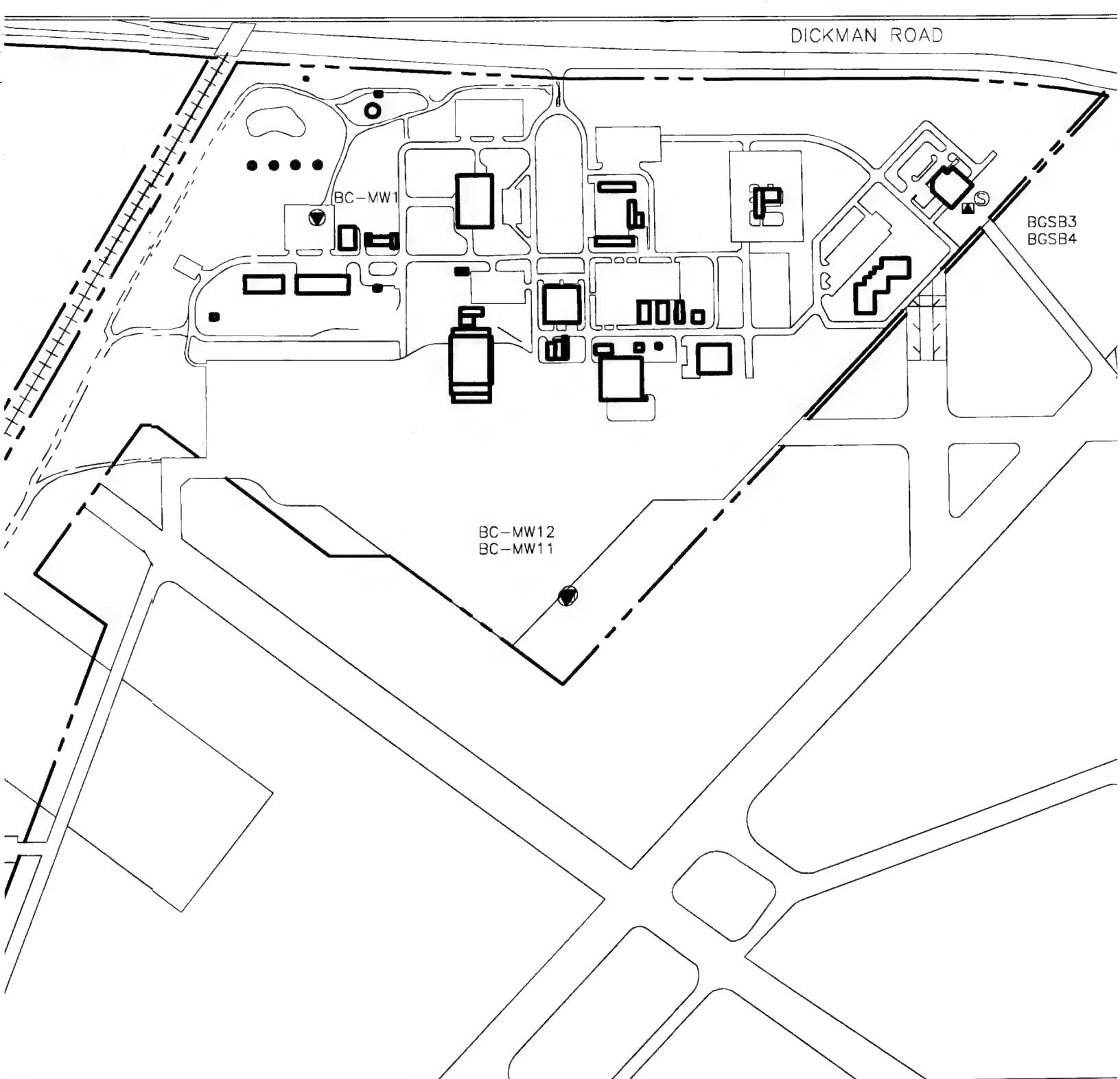
3

Above Ground
Storage Tank
(Pre-existing)
Building

Existing Monitoring Well
Soil Boring
Surface Soil Sample

Note: All features may not appear on this figure.

(2)



toring Well

Sample

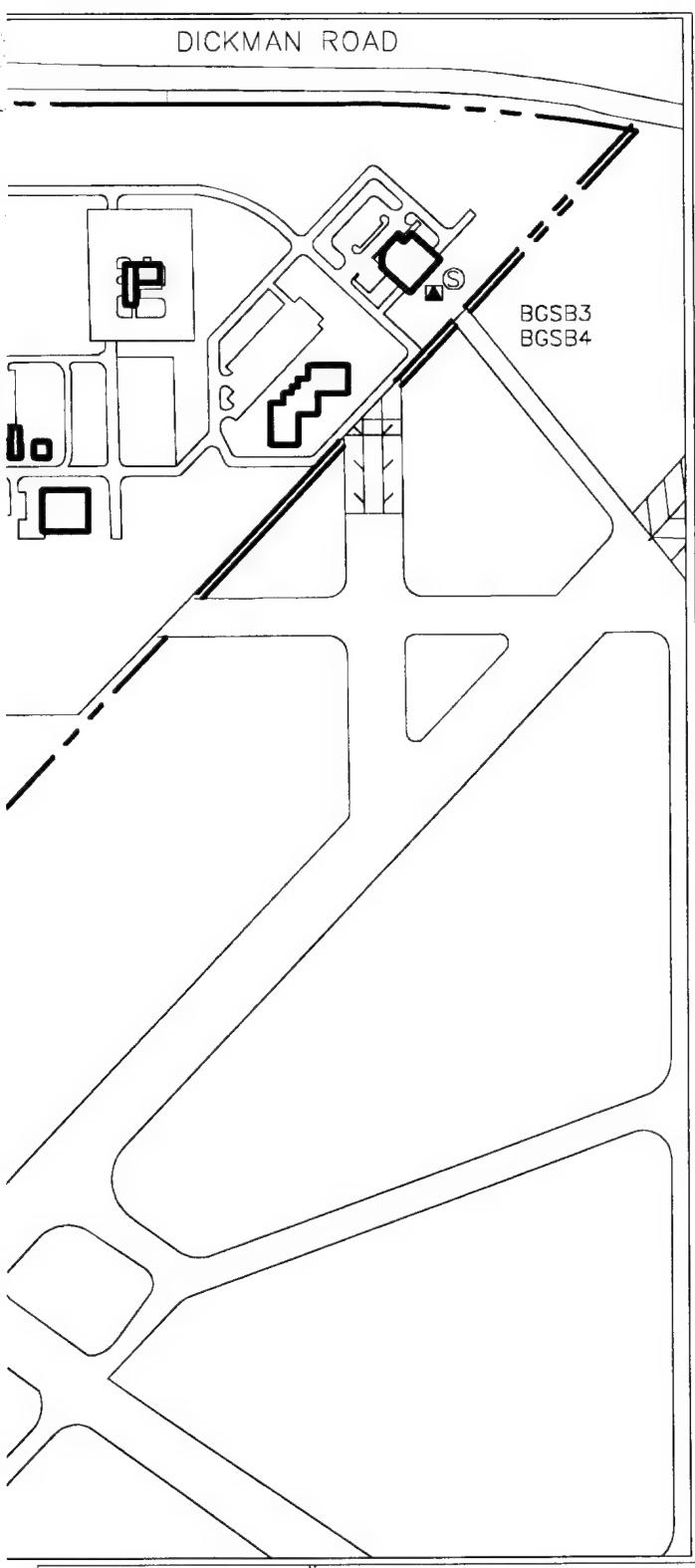
0 100 Feet
Scale 1"=100'

EARTH TECH

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN AIR NATIONAL GUARD
BATTLE CREEK MICHIGAN

SITE 1 AND 3
BACKGROUND SOIL AND
GROUNDWATER SAMPLING LOCATIONS

③



EARTH TECH

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 1 AND 3
BACKGROUND SOIL AND
GROUNDWATER SAMPLING LOCATIONS**

Table 5-1 Background Surface Soil Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BGSB1 BC-BG-SS01	BGSB2 BC-BG-SS02	BGSB3 BC-BG-SS03	BGSB4 BC-BG-SS04
SAMPLE ID:	12/17/94	12/17/94	12/17/94	12/17/94
COLLECTION DATE:	BC-TB3, BC-ER2	BC-TB3, BC-ER2	BC-TB3, BC-ER2	BC-TB3, BC-ER2
ASSOCIATED QC:	BC-FB1, BC-FB2	BC-FB1, BC-FB2	BC-FB1, BC-FB2	BC-FB1, BC-FB2
CRITERIA:	RESULT	QUAL	RESULT	QUAL
Semivolatiles Compounds by CLP (a)			RESULT	QUAL
2-Methylnaphthalene	ID	730	U	730
Acenaphthene	8.1E+8	730	U	730
Acenaphthylene	1.6E+7	730	U	730
Anthracene	1.0E+9	730	U	730
Benzo(a)anthracene	2.1E+5	730	U	730
Benzo(a)pyrene	21000	730	U	730
Benzo(b)fluoranthene	2.1E+5	730	U	730
Benzo(g,h,i)perylene	1.6E+7	730	U	730
Benzo(k)fluoranthene	2.1E+6	730	U	730
Carbazole	(b)	730	U	730
Chrysene	2.1E+7	730	U	730
Di-n-butyl phthalate	5.4E+8	120	U	290
Dibenz(a,h)anthracene	21000	730	U	730
Dibenzofuran	ID	730	U	730
Fluoranthene	5.4E+8	730	U	730
Fluorene	5.4E+8	730	U	730
Indeno(1,2,3-cd)pyrene	2.1E+5	730	U	730
Naphthalene	1.6E+8	730	U	730
Phenanthrene	1.6E+7	730	U	730
Pyrene	3.4E+8	730	U	730
Metals by CLP (c)(d)			RESULT	QUAL
Antimony	0.25	0.210	UJ	0.21
Arsenic	7.14	3	J	2.20
Barium	76.43	36.90	J	13.90
Beryllium	0.19	0.17	0	0.08
Chromium	19.1	6.80	3.60	3.60
Copper	32	4.90	2.60	0
Lead	21	6.50	2.70	11.10
Nickel	20	5.70	3.20	0
Selenium	0.59	0.49	UJ	0.48
Thallium	0.62	0.30	U	0.31
Zinc	47	17.10	J	8

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Data Validation Qualifiers

() Result is between the detection limit and the quantitation limit

B Value is unreliable due to blank contamination value

J Reported value is estimated

U Compound analyzed for but not detected

R Result is unreliable

(a) Results are presented in units of micrograms/kilogram

(b) Criteria does not exist

(c) Results are presented in units of milligrams/kilogram

(d) Samples collected during the Site investigation were analyzed for metals by SW846

BGSB3 and BGSB4 contain one or more of carbazole, dibenzofuran, or individual PAHs, in concentrations ranging from 170 to 29,000 µg/kg.

Metals

As shown in Table 5-1, 11 of the 14 metals analyzed for were quantified in the background surface soil samples. The analytical results obtained from the surface soil analyses were used to calculate background metals concentrations (Section 5.1.3).

5.1.1.2 Subsurface Soil

The analytical results from subsurface soil background sampling are presented in Table 5-2. Each of the subsurface soil background samples were described as yellow to yellow brown sand, medium- to coarse-grained, with a trace of fines or gravel. No laterally extensive subsurface layers composed predominately of silt or clay have been identified within the vadose zone beneath the base. The background samples collected during this investigation are considered compositionally representative of the base subsurface soils.

VOCs

No VOCs were detected in the background subsurface soil samples.

SVOCs

Di-n-butyl phthalate and eight individual PAHs were detected in the background subsurface soil samples. Excluding di-n-butyl phthalate, surface soil samples from locations BGSB1 and BGSB4 were free of SVOCs. Samples collected from locations BGSB2 and BGSB3 contain one or more of the eight PAHs in concentrations ranging from 80 to 470 µg/kg.

Metals

As shown in Table 5-2, 9 of the 14 metals analyzed for were quantified in one or more of the background subsurface soil samples. The analytical results obtained from the subsurface soil

Table 5-2 Background Subsurface Soil Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR: SAMPLE ID:	BGSB1 BC-BG1-05-07 12/17/94 BC-TB3,BC-ER2 BC-FB1, BC-FB2	BGSB2 BC-BG2-05-07 12/17/94 BC-TB3,BC-ER2 BC-FB1, BC-FB2	BGSB3 BC-BG3-05-07 12/17/94 BC-TB3,BC-ER2 BC-FB1, BC-FB2	BGSB4 BC-BG4-05-07 12/17/94 BC-TB3,BC-ER2 BC-FB1, BC-FB2				
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Semivolatile Compounds by CLP (a)								
Benz(a)anthracene	2.1E+5	800	U	710	U	110	0	690
Benzo(a)pyrene	21000	800	U	710	U	92	0	690
Benzol(b)fluoranthene	2.1E+6	800	U	710	U	240	0	690
Benzol(k)fluoranthene	2.1E+6	800	U	710	U	220	0	690
Chrysene	2.1E+7	800	U	710	U	190	0	690
Di-n-butyl phthalate	5.4E+8	140	O	220	O	130	0	230
Fluoranthene	5.4E+8	800	O	80	O	430	0	690
Phenanthrene	1.6E+7	800	U	710	U	470	0	690
Pyrene	3.4E+8	800	U	710	U	370	0	690
Metals by CLP (b)(c)								
Antimony	0.36	0.23	UJ	0.25	OJ	0.20	UJ	0.19
Arsenic	6.57	2.20	J	2.80	J	4.80	J	3.10
Barium	75	6.10	O	6.30	O	6.60	O	8.60
Chromium	18	4		4		4		5.50
Copper	32	4.10		3.80		3.80		3.70
Lead	21	2.90		2.80		2.10		2.50
Nickel	20	4.80	O	4.10	O	4.40		5.50
Thallium	0.45	0.32	U	0.29	U	0.28	UJ	0.32
Zinc	4.7	13.70	J	16.30	J	8.50	J	8.50

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

(a) Results are presented in units of micrograms/kilogram

(b) Results are presented in units of milligrams/kilogram

(c) Samples collected during the Site Investigation were analyzed for metals by SW846

Data Validation Qualifiers

(I) Result is between the detection limit and the quantitation limit

(B) Value is unreliable due to blank contamination value

(J) Reported value is estimated

(R) Compound analyzed for but not detected

(U) Result is unreliable

analyses of these metals were used to calculate background metals concentrations (Section 5.1.3).

5.1.2 Groundwater

Groundwater samples which were used to characterize background conditions were collected from monitoring wells BC-MW9, BC-MW11, BC-MW12, and BC1-MW1. The locations of these wells are shown on Figure 5-1. As is illustrated on Figure 3-7, wells BC-MW11 and BC-MW12 are the base-wide up-gradient wells. BC-MW9 is located on the far western edge of the base; none of the IRP sites identified to date are up-gradient of BC-MW9, while well BC1-MW1 is the up-gradient Site 1 well. The VOC, SVOC, and PP metals analytical groundwater results (filtered) for these four samples are presented on Table 5-3, and are discussed in the following subsections.

VOCs

M- and p-xylene were quantified in relatively low concentrations ($0.18 \mu\text{g/l}$) from the groundwater sample obtained from BC1-MW1. This concentration is below the NREPA PA 451 residential health-based drinking water value for total xylenes. No other samples contained VOCs.

SVOCs

The SVOCs, benzoic acid, di-n-butyl phthalate, and bis (2-ethylhexyl) phthalate were quantified in the groundwater samples in concentrations ranging from 0.5 to $22 \mu\text{g/l}$. The bis (2-ethylhexyl) phthalate detected at a concentration of $22 \mu\text{g/l}$ in groundwater collected from well BC-MW12 was quantified above the NREPA PA 451 residential health-based drinking water value. However, it is probable that this compound is related to laboratory contamination.

Table 5-3 Background Groundwater Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW9	BC-MW9	BC-MW11	BC-MW12	BC1-MW1
SAMPLE ID:	BC-MW9-GW4	BC-MW9-GW4D	BC-MW11-GW4	BC-MW12-GW4	BC1-MW1-GW5D
COLLECTION DATE:	05/23/94	05/23/94	05/23/94	05/23/94	12/18/94
ASSOCIATED QC:	BC-TB5, BC-ER3	BC-TB5, BC-ER3	BC-TB4, BC-ER1	BC-TB4, BC-ER1	BC-TB2, BC-FB1
	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	BC1-MW1-GW5
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
Aromatic Volatiles Compounds by 8020 (a)					
m-Xylene	10000(lb)	0.07	B	0.5	U
p-Xylene	10000(lb)	0.03	B	0.5	U
Semivolatile Compounds by CLP (a)					
Benzoic acid	32000	4	J	3	J
Di-n-butyl phthalate	880	2	B	2	B
bis(2-Ethylhexyl)phthalate	6	1	B	3	B
Metals by CLP (a)(c)					
Aluminum	62.2	188	0	62.20	U
Barium	2000	26.30	(lb)	22.40	(lb)
Calcium	73850	68200	B	67600	B
Copper	1400	10.60	U	1.50	U
Lead	4	2	(lb)	1.80	U
Magnesium	14973	16600	B	16000	B
Manganese	807	167	B	164	B
Potassium	1839	2309.30	U	714	U
Sodium	160000	3100	(lb)	2620	(lb)
Vanadium	64	5.30	U	3.50	U
Zinc	2400	10.30	0	15.80	(lb)
Water Quality Parameters (d)					
Chloride	ID(e)	3.0		3.31	B
Sulfate	ID(e)	10.8		15.2	B
Dissolved Solids	(f)	259		263	B
Nitrate	10	0.4		<0.2	

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA 451 residential health-based drinking water values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(a) Results are presented in units of micrograms/liter

(b) Total Xylenes

(c) Samples collected during the Site investigation were analyzed for metals by SW846

(d) Results are presented in units of milligrams/liter
 (e) Aesthetic drinking water criteria for chloride and sulfate are 250 milligrams/liter

(f) Criteria does not exist

Data Validation Qualifiers

(b) Result is between the detection limit and the quantitation limit

B is unreliable due to blank contamination value

J Reported value is estimated

U Compound analyzed for but not detected

R Result is unreliable

Metals

The metals aluminum, barium, calcium, copper, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc were detected in one or more of the background groundwater samples. The analytical results obtained from the groundwater analyses were used to calculate background metals concentrations for the surficial aquifer (Section 5.1.3).

5.1.3 Background Concentration Determination

Surface and subsurface soil and groundwater background concentrations have been developed and are presented in Table 5-4.

Soils

Background concentrations of metals in the surface and subsurface soils were established by determining the upper limit of background concentrations of a constituent at the mean plus three standard deviations. This is the method recommended by MDNR (April 1994) for establishing soil background concentrations at small sites. The Coefficient of Variation Test (CV) values (Table 5-4) for the background soil data sets range from 0.04 to 0.5, all of which are equal to or below the MDNRs recommended maximum CV of 0.5 for granular soils. In instances where an individual analyte was not detected in all four samples, the Type A default value (MDNR, September 1993) was substituted as the background value. Although some of these samples contain SVOCs, they were not excluded from being considered representative of background conditions which exist on an ANG base, or at an airport.

Groundwater

The data presented in Table 5-3 were used to determine background concentrations for the shallow groundwater beneath the base. Background concentrations for groundwater were established by determining the mean concentration of a particular analyte in the groundwater samples. Where a particular analyte was not detected, one-half of the detection limit was used in the calculation of the mean concentrations.

Table 5-4 Background Surface and Subsurface Soil and Groundwater Concentrations
110th FW MIANG, Battle Creek, Michigan

	MEAN	Standard Deviation (STD)	Background Concentration (MEAN + 3 STD)	CV ^(a)	Type A Value ^(c)	Background ^(d)
Background Surface Soils						
Antimony	0.13	0.04	0.25	0.32	--	0.25
Arsenic	3.39	1.25	7.14	0.37	5.8	7.14
Barium	33.73	14.23	76.43	0.42	75	76.43
Beryllium	0.17	0.01	0.19	0.06	--	0.19
Cadmium ^(b)	(0.05 U)	--	--	--	1.2	1.2
Chromium	7.65	3.82	19.10	0.50	18	19.10
Copper	4.30	1.22	7.96	0.28	32	32
Lead	6.78	3.28	16.61	0.48	21	21
Mercury ^(b)	(0.1 U)	--	--	--	0.13	0.13
Nickel	5.66	1.92	11.43	0.34	20	20
Selenium	0.29	0.10	0.59	0.34	0.41	0.59
Silver ^(b)	(0.5 U)	--	--	--	1.0	1.0
Thallium	0.30	0.11	0.62	0.36	--	0.62
Zinc	14.80	4.83	29.30	0.33	47	47
Background Subsurface Soils						
Antimony	0.14	0.07	0.36	0.5	--	0.36
Arsenic	3.23	1.11	6.57	0.34	5.8	6.57
Barium	6.90	1.15	10.36	0.17	75	75
Beryllium	0.05	0.01	0.08	0.19	--	0.08
Cadmium ^(b)	(0.05 U)	--	--	--	1.2	1.2
Chromium	4.38	0.75	6.63	0.17	18	18
Copper	3.85	0.17	4.37	0.04	32	32
Lead	2.58	0.36	3.65	0.14	21	21
Mercury ^(b)	(0.1 U)	--	--	--	0.13	0.13
Nickel	4.70	0.61	6.52	0.13	20	20
Selenium ^(b)	(0.47 U)	--	--	--	0.41	0.41
Silver ^(b)	(0.5 U)	--	--	--	1.0	1
Thallium	0.19	0.09	0.45	0.47	0.45	0.45
Zinc	11.75	3.90	23.45	0.33	47	47
Background Groundwater						
Aluminum	62.2	--	--	--	--	62.2
Antimony	18.2	--	--	--	--	18.2
Arsenic	1.3	--	--	--	--	1.3
Barium	51.2	--	--	--	--	51.2
Beryllium	0.2	--	--	--	--	0.2
Cadmium	1.8	--	--	--	--	1.8
Calcium	73850.0	--	--	--	--	73850.0
Chromium	2.6	--	--	--	--	2.6
Cobalt	3.1	--	--	--	--	3.1
Copper	5.0	--	--	--	--	5.0
Iron	356.0	--	--	--	--	356.0
Lead	2.2	--	--	--	--	2.2
Magnesium	14972.5	--	--	--	--	14972.5
Manganese	807.3	--	--	--	--	807.3
Mercury	0.1	--	--	--	--	0.1
Nickel	9.2	--	--	--	--	9.2
Potassium	1839.9	--	--	--	--	1839.9
Selenium	1.8	--	--	--	--	1.8
Silver	2.2	--	--	--	--	2.2
Sodium	10217.5	--	--	--	--	10217.5
Thallium	1.3	--	--	--	--	1.3
Vanadium	1.6	--	--	--	--	1.6
Zinc	5.9	--	--	--	--	5.9

soil results are presented in mg/kg

groundwater results are presented in µg/l

(a) CV = coefficient of variation test; test must produce a value below 0.5 to be statistically valid for granular soils, (MDNR, April 1994).

(b) Element was not detected in the background samples.

(c) Type A default values MERA Operational Memorandum #15 (MDNR, September 30, 1993)

(d) Highest of Mean+3 STD or Type A default value.

5.2 BASE-WIDE GEOLOGY AND HYDROGEOLOGY

Activities completed to further understand the base-wide geology and hydrogeology include the following activities:

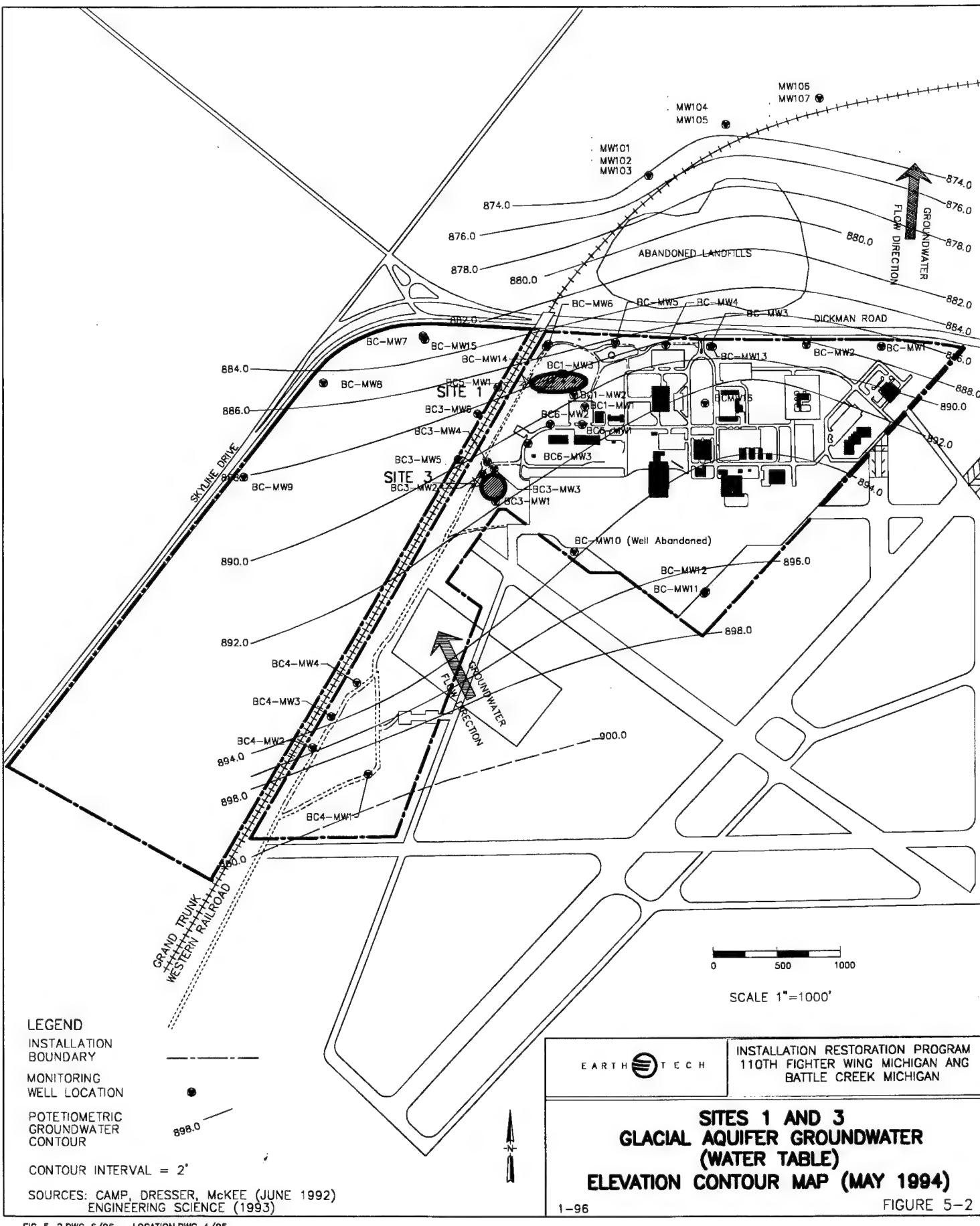
- Collection of two rounds of groundwater elevation measurements (May 1994 and December 1994); May 1994 measurements included the MDNR wells (MW101 through MW107) described in the Springfield Wells Site Final Technical Memorandum (CDM, June 1992).
- Installation of four groundwater monitoring wells; three at Site 1 and one additional well east of Building 6909.

Geology

No base-specific geologic information was obtained during the RI. Soil sampling results and cross sections for the Site 1 investigations are included in Section 5.3.

Hydrogeology

The base-wide hydrogeologic data collected during the RI activities included two rounds of groundwater elevation measurements. These data were collected to further define the nature of groundwater flow within the glacial aquifer beneath the base. The May 1994 and December 1994 groundwater elevation measurements are included in Appendix I and are presented on Figures 5-2 and 5-3. Monitoring well construction details for the wells installed during December 1994 are included in Table 5-5. The groundwater flow patterns shown on Figures 5-2 and 5-3 are consistent with the March 1991 data. These data show that groundwater flow is generally to the north-northwest beneath the base, although on the eastern portion of the base a northeastern component of flow exists. The May 1994 water table elevation map (Figure 5-2) shows that the base is located hydraulically up-gradient from the abandoned landfills (CDM, June 1992) and from the seven monitoring wells (MW101 through MW107) located on the north side of the landfills. The divide, which separates northwesterly flow from northeasterly flow, defined by BC-MW1, -MW2, -MW3, and -MW4



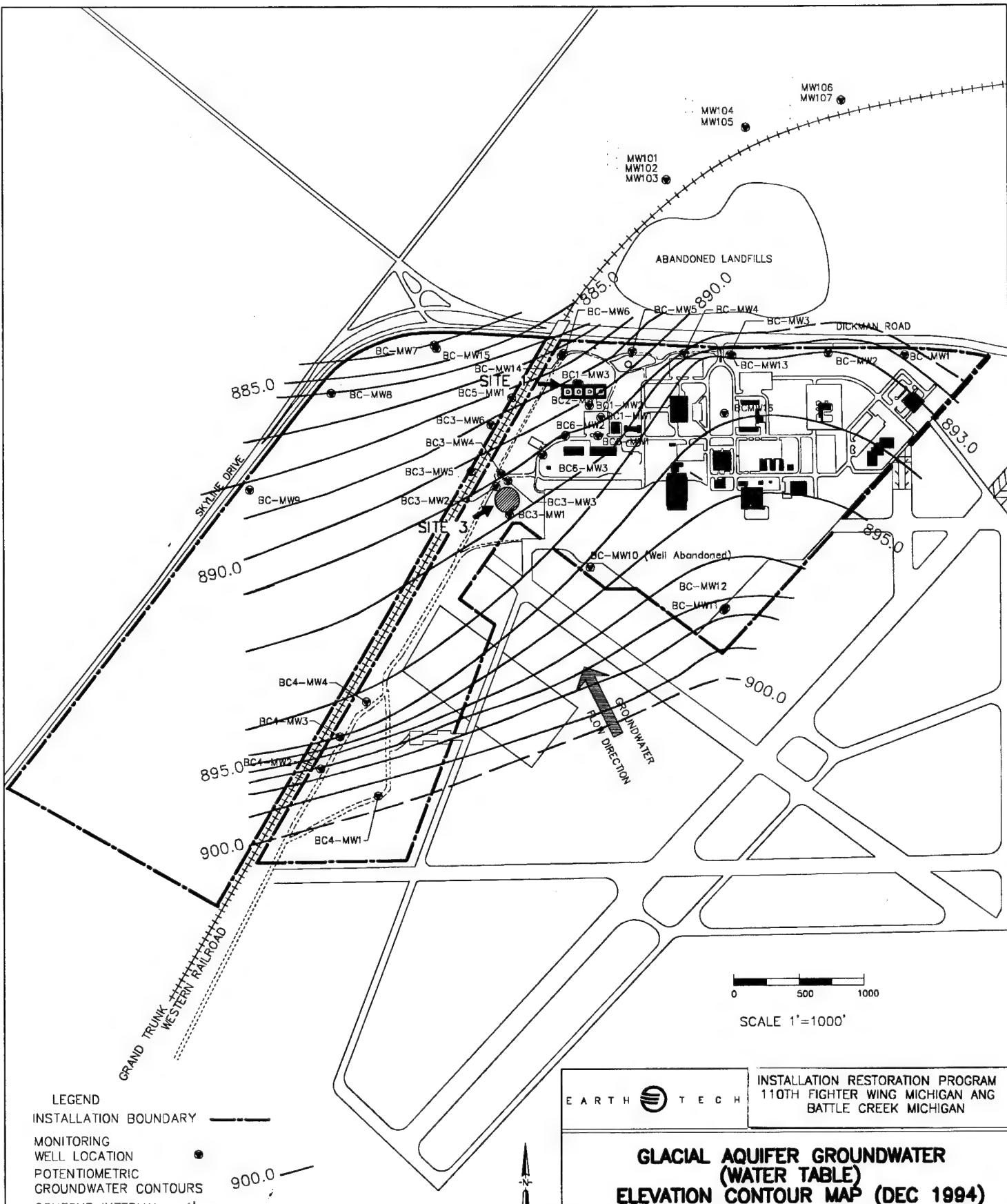


FIGURE 5-3

Table 5-5 Well Construction and Water Table Elevations
110th FW MIANG, Battle Creek, Michigan

Measurement Location	Top of Casing Elevation (Ft AMSL)	Top and Bottom of Screen Elevations (Ft AMSL)	Depth to Water (BTOC) in Ft 12/94	Groundwater Elevation (Ft AMSL) 12/94	Depth to Water (BTOC) in Ft 5/95	Groundwater Elevation (Ft AMSL) 5/95
BC1-MW1	917.94	896.80 - 886.82	27.22	890.72	--	--
BC1-MW2	918.44	893.80 - 883.82	27.95	890.49	28.03	890.41
BC1-MW3	916.06	873.70 - 868.70	26.78	889.28	--	--
BC-MW16	926.85	899.20 - 889.22	32.63	894.22	--	--

Notes:

BTOC - below top of casing

Ft AMSL - feet above mean sea level

was not as evident during May 1994 as it was during March 1991 (Figure 3-8). After the installation and development of wells BC1-MW1, -MW2, -MW3, and BC-MW16 in December 1994 another round of measurements was collected using these four new control points. The December 1994 water table elevation map (Figure 5-3) shows a pattern similar to the March 1991 flow regime; as shown on Figure 5-3, the divide, which is located in the east-central portion of the base, separates northwesterly flow from northeasterly flow and was relatively well-defined when these elevations were obtained.

5.3 SITE 1 - FUEL TANK FARM

The following investigation activities were performed at Site 1:

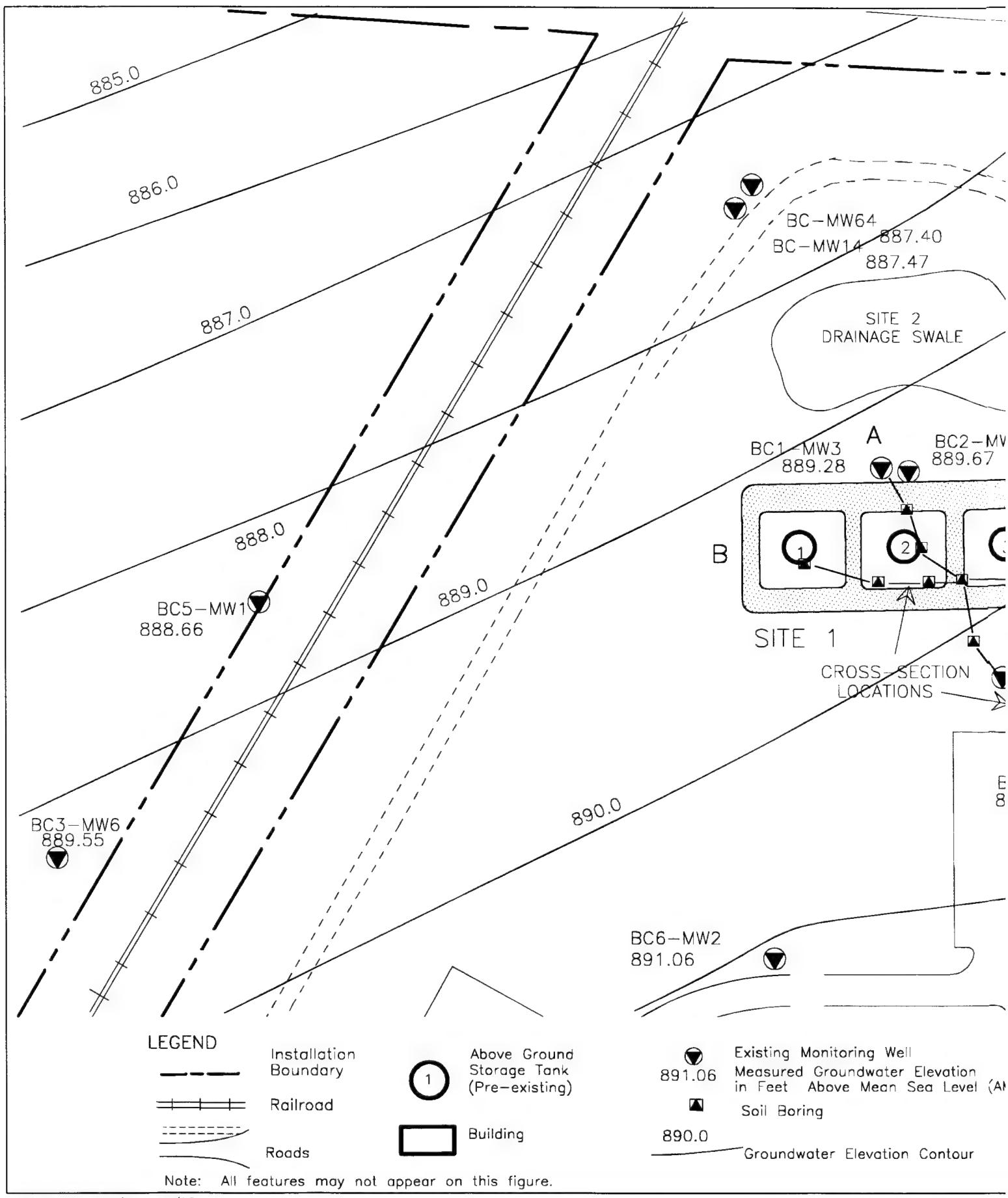
- Twenty-two soil borings (18 Geoprobe® borings and four hollow-stem auger borings) were advanced at the site.
 - Three hollow-stem auger borings were completed as monitoring wells; one of these borings was sampled (soil) at 5 ft intervals from the surface to the water table.
 - One hollow-stem auger boring was used to collect a groundwater sample from and then abandoned.

- Twelve Geoprobe® borings were sampled (soil) at 5 ft intervals from the surface to the water table and then abandoned.
 - Six Geoprobe® borings were sampled (soil) at the 10 to 12 ft bgs interval and then abandoned.
- Eighty soil screening samples were collected using a Geoprobe® unit or a hand auger and were analyzed for PAHs using immunoassay techniques; 34 of these samples were also analyzed for their VOC content using a GC.
- Twenty-one groundwater samples were collected (2 from existing monitoring wells and 19 using a Geoprobe® unit from 13 locations; samples were submitted for VOCs (EPA method 8021 and/or 8260) or SVOCs (EPA method 8270).
- Thirty-three surface and subsurface soil samples were shipped to an analytical laboratory for analyses of VOCs, SVOCs, and lead. Subsequent to the collection and analysis of these samples for lead only, the full PP metals analysis (excluding mercury, but including barium) were obtained for these samples.
- Four groundwater samples were collected from wells BC1-MW1, BC1-MW2, BC1-MW3, and BC2-MW1 and shipped to an analytical laboratory for analyses of VOCs, SVOCs, and PP metals plus barium (filtered only).

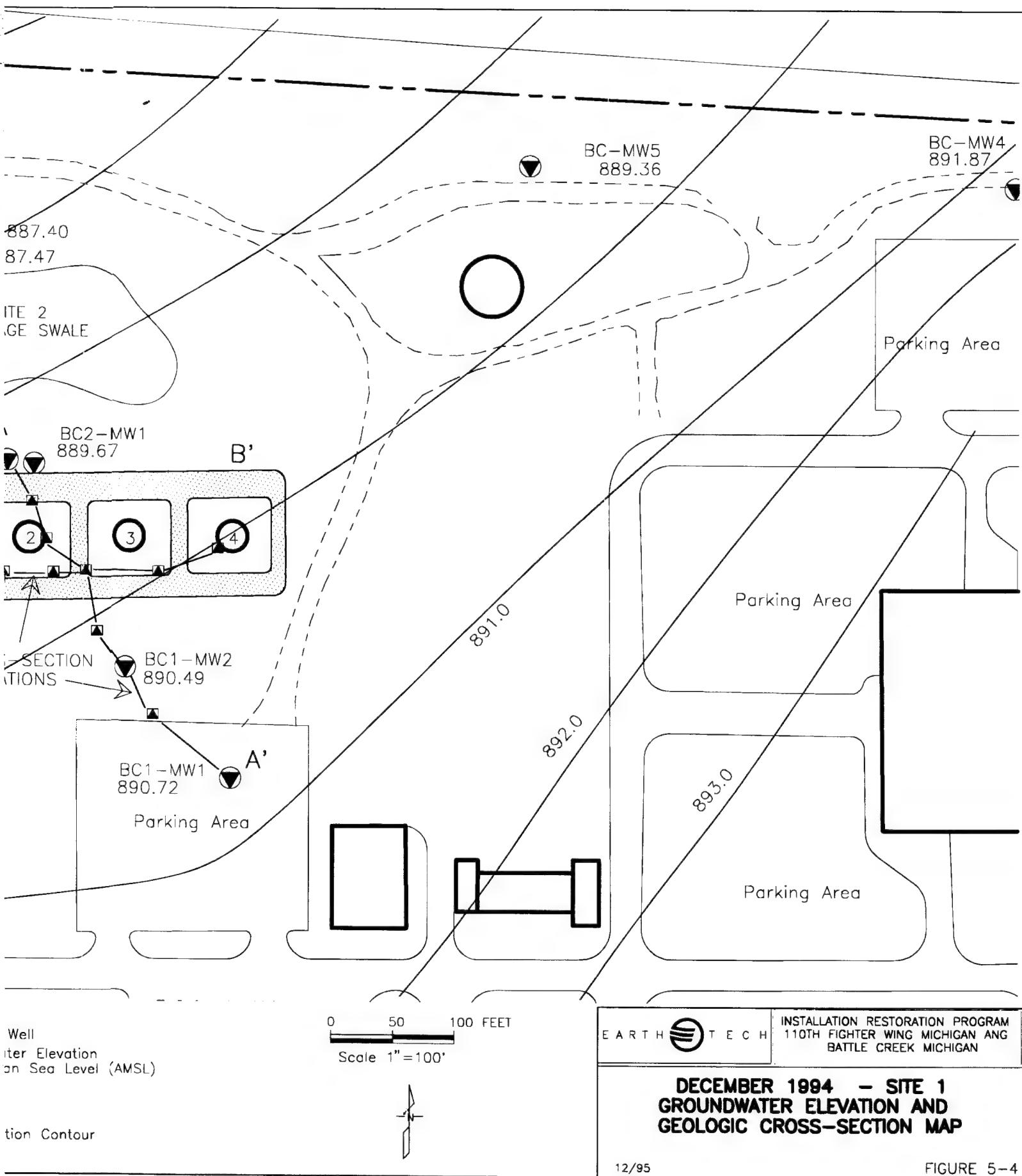
5.3.1 Site Geology and Hydrogeology

Descriptions of the Site 1 geology and hydrogeology are presented in the following sections. Figure 5-4 presents the December 1994 groundwater elevation map for Site 1 and provides the locations of two geologic cross sections (Figures 5-5 and 5-6).

(1)

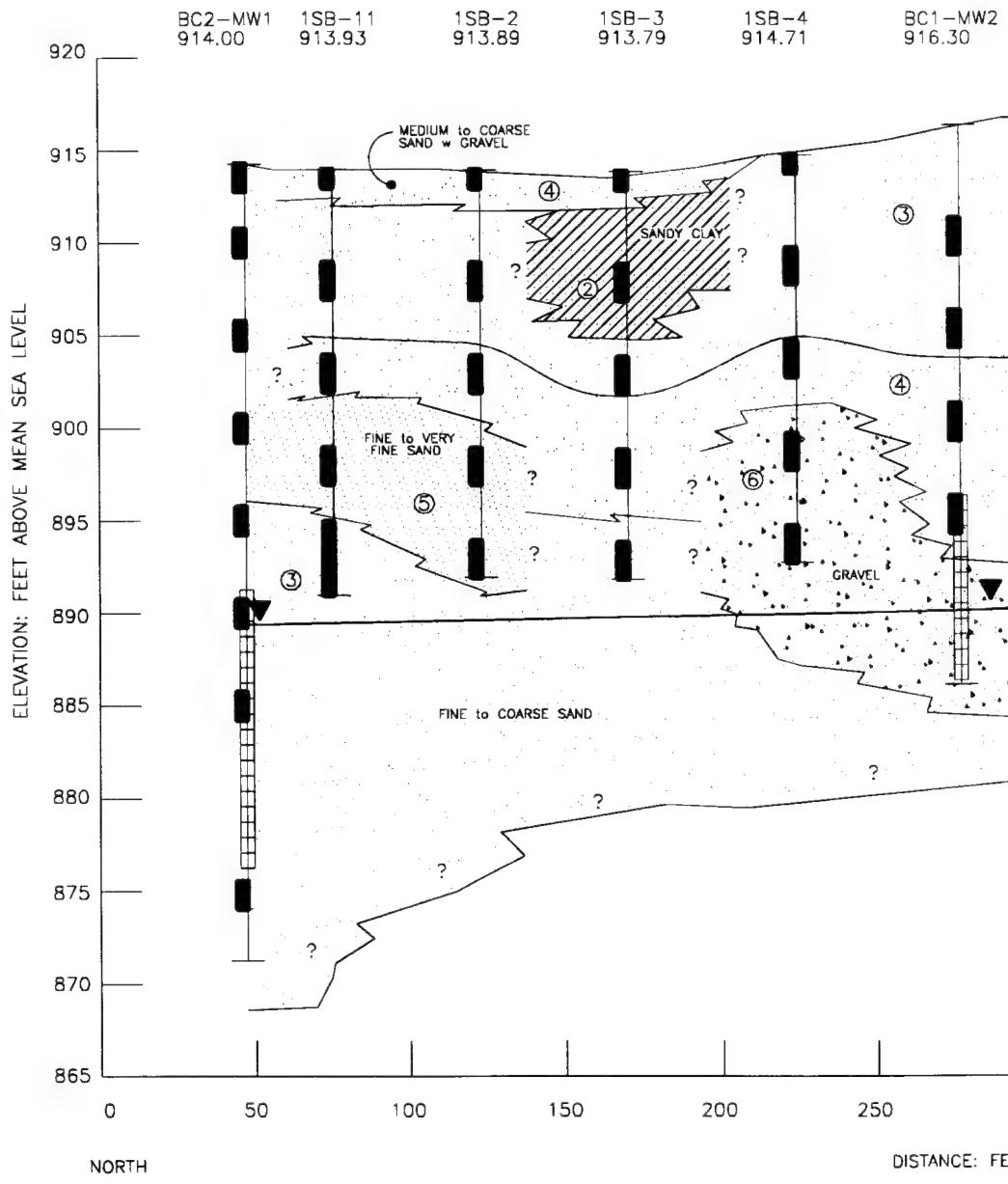


(2)



(1)

A NORTH



LEGEND

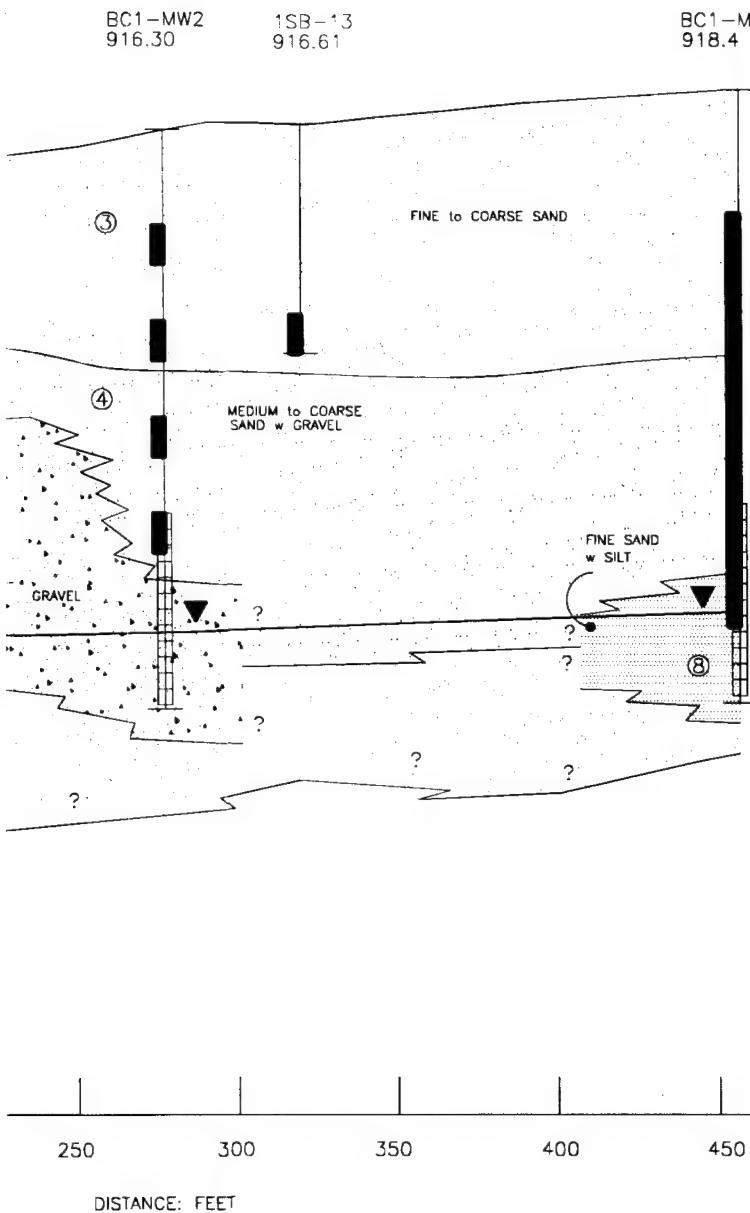
	SANDY CLAY		FINE SAND with SILT
	FINE-COARSE SAND		
	MED-COARSE SAND with GRAVEL		
	FINE - VERY FINE SAND with SILT and CLAY		
	GRAVEL		
			CONTACTS INFERRED
			WATER LEVEL (AS MEASURED DECEMBER 1994)

NOTE VERTICAL EXAGG.
VERTICAL SCALE 1"=10' HORIZONTAL

SB-11
284.48'
BORING IDENTIFICATION
GROUND ELEVATION
IN FEET ABOVE
MEAN SEA LEVEL
SPLIT-SPOON SAMPLE
LOCATION
0.01-INCH SLOT
PVC SCREEN

(2)

A' SOUTH



NOTE VERTICAL EXAGGERATION = 6X
AL SCALE 1"=10' HORIZONTAL SCALE 1'=60'

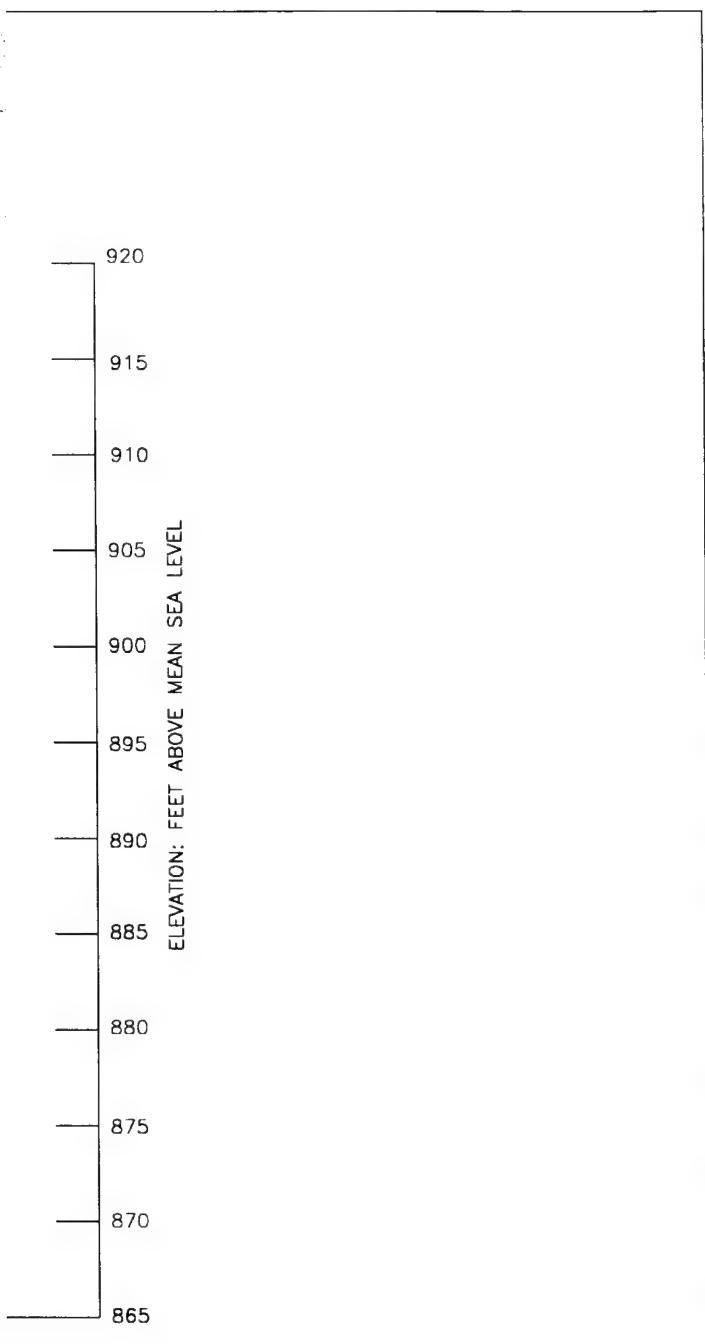
SOUTH



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

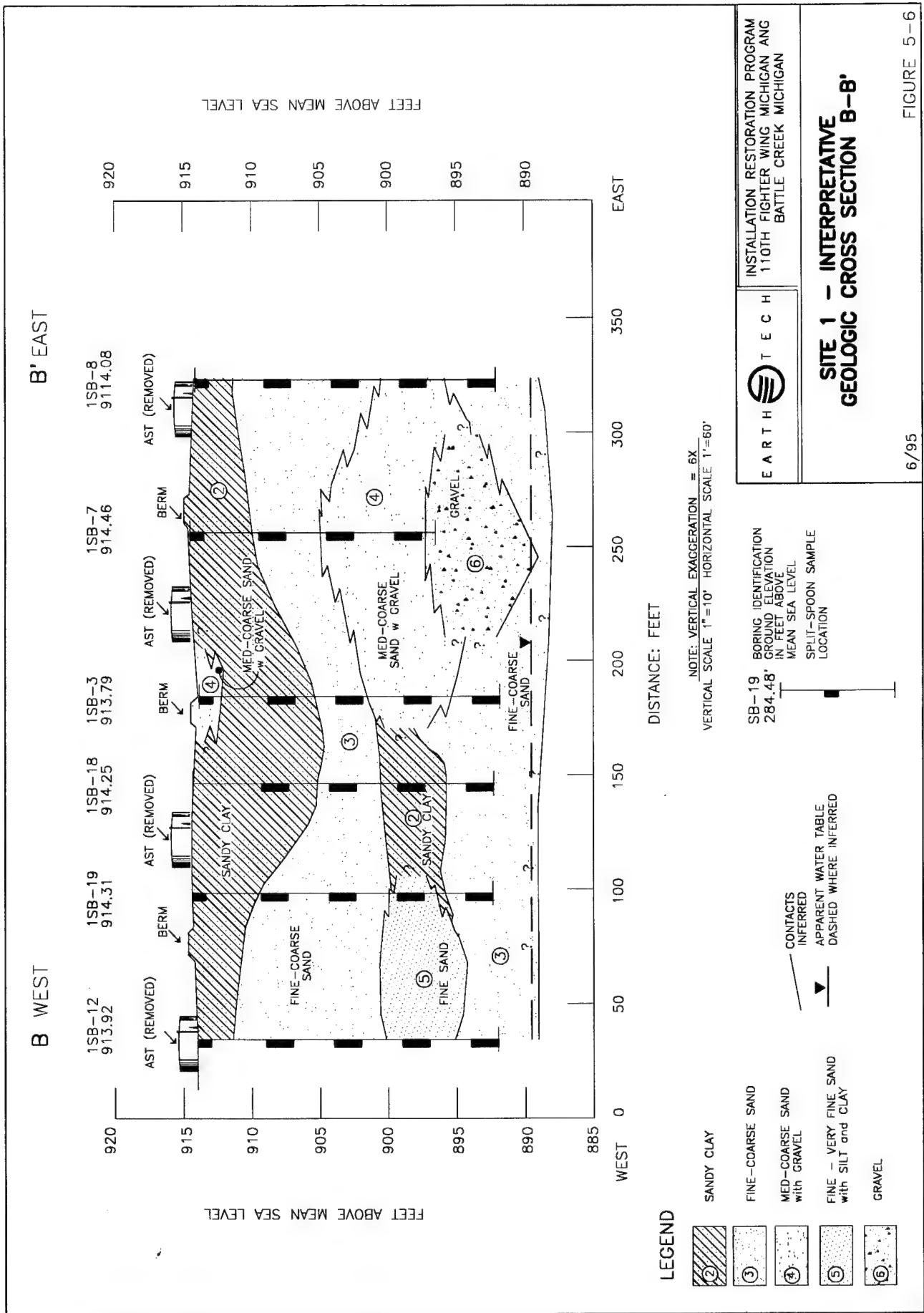
SITE 1 INTERPRETATIVE
GEOLOGIC CROSS SECTION A-A'

(3)



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 1 INTERPRETATIVE
GEOLOGIC CROSS SECTION A-A'**



Geology

The geologic descriptions of the glacial drift underlying Site 1 were obtained from field observations completed during the drilling and sampling operations. Monitoring well BC1-MW1 was the only borehole advanced during the field operations that was continuously cored; the remaining boreholes were sampled at 5 ft intervals.

As is illustrated on Figures 5-5 and 5-6, the glacial drift beneath Site 1 consists primarily of fine- to coarse-grained quartz sand, which contains varying amounts of clay, silt, and/or gravel. A fine-grained, sandy clay unit was logged below the four former ASTs. This unit occurs at relatively shallow depths (0 to 2 ft bgs) and ranges in thickness from approximately 2 to 10 ft. This unit was not described in the subsurface samples collected from the southern end of the site (Figure 5-6). Beneath the sandy clay, a fine- to coarse-grained sand unit exists. This unit is underlain by a layer of interbedded sand, clayey sand and gravel. A lower sand unit underlies the interbedded sand, clayey sand and gravel below the AST area.

Hydrogeology

The groundwater contained in the glacial aquifer beneath Site 1 occurs at an average depth of approximately 25 ft bgs. Groundwater flow beneath the site is to the northwest at an average hydraulic gradient of 0.006 (Figure 5-4). As is also shown on Figure 5-4, well BC1-MW1 is located up-gradient of Site 1. Well BC1-MW2 was installed within the area of the site which contained the highest groundwater screening concentrations, while BC2-MW1 and BC1-MW3 (vertical extent well) are monitoring groundwater quality down-gradient of BC1-MW2.

Hydraulic conductivity values for the surficial aquifer beneath Site 1 averages 1.4×10^{-2} cm/sec (39 ft/day). These data were obtained from the slug-testing results for well BC2-MW1 (ES, 1993). The groundwater velocity (v) beneath Site 1 is 245 ft/yr (0.67 ft/day), which was calculated using the following equation (Freeze and Cherry, 1979):

$$v = \frac{k}{n} \times \frac{dh}{dl}$$

where:

k = hydraulic conductivity

n = porosity (assumed to be 35% for unconsolidated glacial drift)

$\frac{dh}{dl}$ = hydraulic gradient

5.3.2 Soil Analytical Results

Discussions of the Site 1 and AOC B analytical results are presented in the following subsections. A complete discussion of the results of the AOC B investigations can be found in the Final PA/Site Inspection Report (EARTH TECH, April 1996). The only data reproduced from this report are the information needed to complete the risk evaluation at this area.

Soil screening results for Site 1 will be presented for the site surface and subsurface soils. These data will be followed by a discussion of the confirmation results for both media. The concentration of a particular analyte was averaged when a sample and a field duplicate sample are presented in the data set. One-half of the detection limit was used in the calculation if a particular analyte was not detected in either the sample or the field duplicate.

5.3.2.1 Surface Soils

The analytical results for the immunoassay screening for PAHs and GC analyses for VOCs are included in Appendix B. Samples selected for confirmation analysis are indicated on the data tables presented in this appendix. The analytical data for the confirmation surface soil sampling are presented in Table 5-6. The data presented in Table 5-6 corresponds to the sampling locations shown on Figure 5-7.

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-1	1SB-1	1SB-2	1SB-3	1SB-4
SAMPLE ID:	BC1-B1-00-01	BC1-B1-00-01D	BC1-B2-00-01	BC1-B3-00-01	BC1-B4-00-01
COLLECTION DATE:	11/07/94	11/07/94	11/07/94	11/07/94	11/09/94
ASSOCIATED QC:	BC-TB2, BC-ER5	BC-TB2, BC-ER5	BC-TB2, BC-ER5	BC-TB1, BC-ER6	BC-TB4, BC-ER6
	BC-FB3, BC-FB6				
CRAITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
CRAITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
Volatile Compounds by 8240 (a)					
Acetone	7.4E+7	14	B	16	B
Methylene chloride	3.3E+6	12	B	14	B
Tetrachloroethene	4.9E+5	6	U	6	U
Semivolatiles Compounds by CLP (a)					
2-Methylnaphthalene	ID	170	0	380	U
Acenaphthene	8.1E+8	700	46	380	30
Acenaphthylene	1.6E+7	380	U	380	370
Anthracene	1.0E+9	200	0	380	370
Benzo(a)anthracene	2.1E+5	280	0	380	43
Benzo(a)pyrene	21000	210	0	380	42
Benzo(b)fluoranthene	2.1E+5	370	0	48	55
Benzo(g,h,i)perylene	1.6E+7	140	0	380	90
Benzo(k)fluoranthene	2.1E+6	390	51	380	220
Carbazole	(b)	98	0	380	0
Chrysene	2.1E+7	250	0	380	95
Di-n-butyl phthalate	5.4E+8	380	70	380	940
Dibenz(a,h)anthracene	21000	380	0	380	370
Dibenzofuran	ID	320	0	380	U
Fluoranthene	5.4E+8	780	94	77	39
Fluorene	5.4E+8	290	0	380	530
Indeno(1,2,3-cd)pyrene	2.1E+5	120	0	380	730
Naphthalene	1.6E+8	110	0	380	61
Phenanthrene	1.6E+7	990	85	380	370
Pyrene	3.4E+8	580	71	380	750
bis(2-Ethylhexyl)phthalate	1.1E+7	380	U	380	110
Metals by CLP (c)(d)					
Antimony	0.25	0.13	UJ	0.14	UJ
Arsenic	7.14	3.90	4.30	1.90	5.60
Barium	76.43	32.70	27.90	9.60	25
Beryllium	0.19	0.21	0	0.07	0.21

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID	Insufficient data available to develop criteria
NS	Not Sampled
Result Qualifiers	
(I)	Result is between the detection limit and the quantitation limit
(II)	Value is unreliable due to blank contamination value
(J)	Reported value is estimated
(b)	Compound analyzed for but not detected
(c)	Results are presented in units of milligrams/kilogram
(d)	Samples collected during the Site investigation were analyzed for metals by SW446

Laboratory Qualifiers	
A	Result produced from a single point method-of-standard addition
B	Analyte also detected in associated blank (organic)
B	Result between IDL and CRDL (inorganic)
E	Chemical or physical interference during analysis
J	Reported value is estimated
N	Matrix related interference in the sample
U	Compound analyzed for but not detected
W	Slight matrix related interference
X	Sample specific qualifier
*	Non-homogeneous sample matrix

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)

LOCATOR:	1SB-1 BC1-B1-00-01	1SB-1 BC1-B1-00-01D	1SB-2 BC1-B2-00-01	1SB-3 BC1-B3-00-01	1SB-4 BC1-B4-00-01
SAMPLE ID:	11/07/94	11/07/94	11/07/94	11/07/94	11/09/94
COLLECTION DATE:	BC-TB2, BC-ER5	BC-TB2, BC-ER5	BC-TB2, BC-ER5	BC-TB1, BC-ER5	BC-TB4, BC-ER6
ASSOCIATED QC:	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BC-FB3, BC-FB6
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
Cadmium	1.2	0.03	U	0.03	U
Chromium	19.1	8.70	8.20	4.40	8.80
Chromium, Cr + 6 (1)	22	-	-	-	-
Copper	32	5.70	6.30	6.90	7.80
Lead	21	24.80	29.90	37.50	52.60
Nickel	20	7.10	7.50	4.60	8.10
Selenium	0.59	0.32	0.32	0.31	0.31
Silver	1.0	0.04	0.05	0.04	0.04
Thallium	0.62	0.33	0.35	0.33	0.33
Zinc	47	17.60	J	18.20	J
				24.30	J
				25.50	J
				19	J
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
Cadmium	1.2	0.03	U	0.03	U
Chromium	19.1	8.70	8.20	4.40	8.80
Chromium, Cr + 6 (1)	22	-	-	-	-
Copper	32	5.70	6.30	6.90	7.80
Lead	21	24.80	29.90	37.50	52.60
Nickel	20	7.10	7.50	4.60	8.10
Selenium	0.59	0.32	0.32	0.31	0.31
Silver	1.0	0.04	0.05	0.04	0.04
Thallium	0.62	0.33	0.35	0.33	0.33
Zinc	47	17.60	J	18.20	J
				24.30	J
				25.50	J
				19	J

Criteria for organic compounds are the NIREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- D Result between detection limit and the quantitation limit
- O Value is unreliable due to blank contamination value
- B Reported value is estimated
- J Compound analyzed for but not detected
- U Compound analyzed for but not detected
- R Result is unreliable

(1) Results are presented in units of milligrams/kilogram

(a) Results are presented in units of micrograms/kilogram

(b) Criteria does not exist

(c) Results are presented in units of milligrams/kilogram

(d) Samples collected during the Site investigation were analyzed for metals by SW846

Result Qualifiers

- (1) Results are presented in units of milligrams/sliter
- (a) Results are presented in units of micrograms/kilogram
- (b) Criteria does not exist
- (c) Results are presented in units of milligrams/kilogram
- (d) Samples collected during the Site investigation were analyzed for metals by SW846

Laboratory Qualifiers

- A Result produced from a single point method-of-standard addition
- B Analyte also detected in associated blank (organic)
- E Result between IDL and CRDL (inorganic)
- F Chemical or physical interference during analysis
- J Reported value is estimated
- M Matrix related interference in the sample
- U Compound analyzed for but not detected
- V Slight matrix related interference
- X Sample specific qualifier
- * Non-homogeneous sample matrix

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-5	1SB-7	1SB-8	1SB-9	1SB-11
SAMPLE ID:	BC1-B5-00-01D	BC1-B7-00-01	BC1-B8-00-01	BC1-B9-00-01	BC1-B11-00-01
COLLECTION DATE:	11/09/94	11/09/94	11/09/94	11/10/94	11/09/94
ASSOCIATED QC:	BC-TB4, BC-ER6 BC-FB3, BC-FB6	BC-TB4, BC-ER7 BC-FB3, BC-FB6	BC-TB4, BC-ER6 BC-FB3, BC-FB6	BC-TB4, BC-ER6 BC-FB3, BC-FB6	BC-TB4, BC-ER6 BC-FB3, BC-FB6
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT
Volatile Compounds by 8240 (a)					
Acetone	7.4E + 7	11	U	11	U
Methylene chloride	3.3E + 6	15	B	8	(B)
Tetrachloroethene	4.9E + 5	5	U	6	UJ
Semi-volatiles Compounds by CLP (a)					
2-Methylnaphthalene	ID	360	U	370	U
Acenaphthene	8.1E + 8	360	U	370	U
Acenaphthylene	1.6E + 7	360	U	51	0
Anthracene	1.0E + 9	360	U	75	0
Benz(a)anthracene	2.1E + 5	79	0	800	470
Benz(a)pyrene	21000	87	0	740	600
Benz(b)fluoranthene	2.1E + 5	190	0	1600	960
Benz(g,h)perylene	1.6E + 7	62	0	300	0
Benz(k)fluoranthene	2.1E + 6	200	0	1600	1000
Carbazole	(b)	360	U	42	0
Chrysene	2.1E + 7	98	0	840	490
Di-n-butyl phthalate	5.4E + 8	47	0	50	0
Dibenz(a,h)anthracene	21000	360	U	100	0
Dibenzofuran	ID	360	U	370	U
Fluoranthene	5.4E + 8	140	0	1100	600
Fluorene	5.4E + 8	360	U	38	0
Indeno[1,2,3-cd]pyrene	2.1E + 5	68	0	330	0
Naphthalene	1.6E + 8	360	U	370	U
Phenanthrene	1.6E + 7	56	0	390	150
Pyrene	3.4E + 8	130	0	1100	660
bis(2-Ethylhexyl)phthalate	1.1E + 7	360	U	370	U
Metals by CLP (c)(d)					
Antimony	0.25	0.13	UJ	0.15	(J)
Arsenic	7.14	5.70		5.90	6.10
Barium	76.43	28.70	0.21	49.10	38.80
Beryllium	0.19	0.21	0	0.30	0.19

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- I Result between the detection limit and the quantitation limit
- B Value is unreliable due to blank contamination value
- J Reported value is estimated
- U Compound analyzed for but not detected
- R Result is unreliable

Result Qualifiers

- A Result produced from a single point method-of-standard addition
- B Analyte also detected in associated blank (organic)
- E Result between IDL and CRDL (inorganic)
- J Chemical or physical interference during analysis
- K Reported value is estimated
- N Matrix related interference in the sample
- V Compound analyzed for but not detected
- W Slight matrix related interference
- X Sample specific qualifier
- * Non-homogeneous sample matrix

Laboratory Qualifiers

- A Result produced from a single point method-of-standard addition
- B Analyte also detected in associated blank (organic)
- E Result between IDL and CRDL (inorganic)
- J Chemical or physical interference during analysis
- K Reported value is estimated
- N Matrix related interference in the sample
- V Compound analyzed for but not detected
- W Slight matrix related interference
- X Sample specific qualifier
- * Non-homogeneous sample matrix

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

- (1) Results are presented in units of milligrams/liter
- (a) Results are presented in units of micrograms/kilogram
- (b) Criteria does not exist
- (c) Results are presented in units of milligrams/kilogram
- (d) Samples collected during the Site investigation were analyzed for metals by SW846

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

D Insufficient data available to develop criteria
NS Not Sampled

Results are presented in units of milligrams/liter

Results are presented in units of micrograms/kilogram

(a) Criteria does not exist

(b) Results are presented in units of milligrams/kilogram

(c) Samples collected during the Site Investigation were analyzed for metals

A Result produced from a single point method-of-standard addition

B Analyte also detected in associated blank (organic)

B Result between IDL and CRDL (inorganic)

Chemical or physical interference during analysis generated value is estimated

Matrix related interference in the sample

Compound analyzed for but not detected

W Slight matrix related interference
 X Sample specific qualifier
 * Non-homogeneous sample matrix

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Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-19	1SS-11	1SS-12	1SS-13	1SS-14	BSB-1
SAMPLE ID:	BC1-B19-00-01	BC1-SS11	BC1-SS12	BC1-SS13	BC1-SS14	BCB-B1-0002
COLLECTION DATE:	11/10/94	12/18/94	12/18/94	12/18/94	12/18/94	07/13/94
ASSOCIATED QC:	BC-TB4, BC-ER7	BC-TB3	BC-TB3	BC-TB3	BC-TB3	BCER4
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Volatile Compounds by 8240 (a)						
Acetone	7.4E+7	13	B	-	-	-
Methylene chloride	3.3E+6	12	B	-	-	-
Tetrachloroethene	4.9E+5	6	U	-	-	-
Semi挥发性 Compounds by CLP (a)						
2-Methylnaphthalene	ID	370	U	730	740	720
Acenaphthene	8.1E+8	370	U	730	740	720
Acenaphthylene	1.6E+7	370	U	730	740	720
Anthracene	1.0E+9	370	U	730	740	720
Benz(a)anthracene	2.1E+5	370	U	730	740	720
Benz(a)pyrene	21000	370	U	730	740	720
Benz(b)fluoranthene	2.1E+5	370	U	730	740	720
Benz(g,h,i)perylene	1.6E+7	370	U	730	740	720
Benz(k)fluoranthene	2.1E+6	370	U	730	740	720
Carbazole	(b)	370	U	730	740	720
Chrysene	2.1E+7	370	U	730	740	720
Di-n-butyl phthalate	5.4E+8	54	O	730	740	720
Dibenz(a,h)anthracene	21000	370	U	730	740	720
Dibenzofuran	ID	370	U	730	740	720
Fluoranthene	5.4E+8	370	U	730	740	720
Fluorene	5.4E+8	370	U	730	740	720
Indeno[1,2,3-cd]pyrene	2.1E+5	370	U	730	740	720
Naphthalene	1.6E+8	370	U	730	740	720
Phenanthrene	1.6E+7	370	U	730	740	720
Pyrene	3.4E+8	370	U	730	740	720
bis(2-Ethyhexyl)phthalate	1.1E+7	370	U	730	740	720
Metals by CLP (c)(d)						
Antimony	0.25	0.17	IJ	R	R	R
Arsenic	7.14	5.70	J	5.90	8.50	4.80
Barium	76.43	30.20	O	20.30	33.10	17.70
Beryllium	0.19	0.24	O	0.29	0	0.40
					0.29	0
					0.40	0
					0.16	0
					0.21	B

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(I) Result is between the detection limit and the quantitation limit

(O) Value is unreliable due to blank contamination value

(R) Reported value is estimated

(J) Compound analyzed for but not detected

(U) Result is unreliable

(W) Slight matrix related interference

(X) Sample specific qualifier

(Y) Non-homogeneous sample matrix

Data Validation Qualifiers

(A) Result produced from a single point method-of-standard addition

(B) Analyte also detected in associated blank (organic)

(C) Result between IDL and CRDL (inorganic)

(E) Chemical or physical interference during analysis

(J) Reported value is estimated

(N) Matrix related interference for the detected compound

(U) Compound analyzed for but not detected

(W) Slight matrix related interference

(X) Sample specific qualifier

(Y) Non-homogeneous sample matrix

Laboratory Qualifiers

(A) Result produced from a single point method-of-standard addition

(B) Analyte also detected in associated blank (organic)

(C) Result between IDL and CRDL (inorganic)

(E) Chemical or physical interference during analysis

(J) Reported value is estimated

(N) Matrix related interference for the detected compound

(U) Compound analyzed for but not detected

(W) Slight matrix related interference

(X) Sample specific qualifier

(Y) Non-homogeneous sample matrix

Data Validation Qualifiers

(A) Result produced from a single point method-of-standard addition

(B) Analyte also detected in associated blank (organic)

(C) Result between IDL and CRDL (inorganic)

(E) Chemical or physical interference during analysis

(J) Reported value is estimated

(N) Matrix related interference for the detected compound

(U) Compound analyzed for but not detected

(W) Slight matrix related interference

(X) Sample specific qualifier

(Y) Non-homogeneous sample matrix

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-19	1SS-11	1SS-12	1SS-13	1SS-14	BSB-1
SAMPLE ID:	BC1-B19-00-01	BC1-SS11	BC1-SS12	BC1-SS13	BC1-SS14	BCB-B1-0002
COLLECTION DATE:	11/10/94	12/18/94	12/18/94	12/18/94	12/18/94	07/13/94
ASSOCIATED QC:	BC-TB4, BC-ER7	BC-TB3	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BCER4
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Cadmium	1.2	0.03	U	0.22	IJ	0.07
Chromium	19.1	8.80	-	9.70	J	16.80
Chromium, Cr+6 (1)	22	-	-	-	J	6.20
Copper	32	6.50	-	8.20	-	-
Lead	21	7.70	-	9.60	9.70	12.50
Nickel	20	7.80	-	8.40	6.50	8.40
Nickel	0.59	0.32	UJ	1.10	J	10.80
Selenium	1.0	0.05	UJ	0.49	0.58	0.60
Silver	0.62	0.34	U	0.33	UJ	0.60
Thallium	47	17.10	J	22.70	J	0.60
Zinc	-	-	-	-	0.34	0.31
					J	24.40
					J	21.30
					J	13.70
					J	22.70
					J	17.10
					J	47

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- I) Result is between the detection limit and the quantitation limit
- B) Value is unreliable due to blank contamination value
- J) Reported value is estimated
- U) Compound analyzed for but not detected
- R) Result is unreliable

(1) Results are presented in units of milligrams/liter

(a) Results are presented in units of micrograms/kilogram

(b) Criteria does not exist

(c) Results are presented in units of milligrams/kilogram

(d) Samples collected during the Site Investigation were analyzed for metals by SWBAG6

Laboratory Qualifiers

- A) Result produced from a single point method-of-standard addition
- B) Analyte also detected in associated blank (organic)
- B) Result between IDL and CRDL (inorganic)
- E) Chemical or physical interference during analysis
- J) Reported value is estimated
- N) Matrix related interference in the sample
- U) Compound analyzed for but not detected
- W) Slight matrix related interference
- X) Sample specific qualifier
- *
- Non-homogeneous sample matrix

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)

LOCATOR:	BSB-2	BSB-3	BSB-4
SAMPLE ID:	BCB-B2-0002	BCB-B3-0002	BCB-B4-0002
COLLECTION DATE:	07/13/94	07/13/94	07/13/94
ASSOCIATED QC:	BCER4	BCER4	BCER6
CRAITERIA:	RESULT	QUAL	RESULT
Volatile Compounds by 8240 (a)			
Acetone	7.4E+7	37	B
Methylene chloride	3.3E+6	14	B
Tetrachloroethene	4.9E+5	1	J
Semivolatile Compounds by CLP (a)			
2-Methylnaphthalene	ID	350	U
Acenaphthene	8.1E+8	350	U
Acenaphthylene	1.6E+7	350	U
Anthracene	1.0E+9	70	J
Benz(a)anthracene	2.1E+5	310	J
Benz(a)pyrene	21000	210	J
Benz(b)fluoranthene	2.1E+5	440	X
Benz(g,h,i)perylene	1.6E+7	120	J
Benz(k)fluoranthene	2.1E+6	600	X
Carbazole	(b)	350	U
Chrysene	2.1E+7	260	J
Di-n-butyl phthalate	5.4E+8	350	U
Dibenz(a,h)anthracene	21000	30	J
Dibenzofuran	ID	350	U
Fluoranthene	5.4E+8	410	U
Fluorene	5.4E+8	350	U
Indeno(1,2,3-cd)pyrene	2.1E+5	160	J
Naphthalene	1.6E+8	350	U
Phenanthrene	1.6E+7	210	J
Pyrene	3.4E+8	330	J
bis(2-Ethylhexyl)phthalate	1.1E+7	160	J
Metals by CLP (c)(d)			
Antimony	0.25	3.20	UN
Arsenic	7.14	3	AN
Barium	76.43	-	-
Beryllium	0.19	0.16	B

Criteria for organic compounds are the NREPA PA 451 industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria
NS Not Sampled

Result Qualifiers
(1) Results are presented in units of milligrams/liter
(2) Results are presented in units of micrograms/kilogram
(3) Criteria does not exist
(4) Results are presented in units of milligrams/kilogram
(d) Samples collected during the Site investigation were analyzed for metals by SW846

Laboratory Qualifiers
A Result produced from a single point method-of-standard addition
B Analyte also detected in associated blank (organic)
B Result between IDL and CRDL (inorganic)
E Chemical or physical interference during analysis
J Reported value is estimated
N Matrix related interference in the sample
U Compound analyzed for but not detected
V Slight matrix related interference
X Sample specific qualifier
+ Non-Homogeneous sample matrix

Data Validation Qualifiers
I Result is between the detection limit and the quantitation limit
B Value is unreliable due to blank contamination value
J Reported value is estimated
R Result is unreliable

Table 5-6 Site 1 / Area of Concern B Surface Soil Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BSB-2	BSB-3	BSB-4
SAMPLE ID:	BCB-B2-0002 07/13/94 BCER4	BCB-B3-0002 07/13/94 BCER4	BCB-B4-0002 07/13/94 BCER6
COLLECTION DATE:			
ASSOCIATED QC:			
CRITERIA:	RESULT	QUAL	RESULT
	RESULT	QUAL	RESULT
Cadmium	1.2	2.70	N
Chromium	19.1	58.10	N
Chromium, Cr + 6 (1)	22	0.02	0
Copper	32	24.60	U
Lead	21	200	13.70
Nickel	20	4.30	9
Selenium	0.59	0.42	UWN
Silver	1.0	0.43	U
Thallium	0.62	0.38	U
Zinc	47	112	EN
			RESULT
			QUAL

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers		Laboratory Qualifiers	
I	Result is between the detection limit and the quantitation limit	A	Result produced from a single point method-of-standard addition
B	Value is unreliable due to blank contamination value	B	Analyte also detected in associated blank (organic)
J	Reported value is estimated	B	Result between IDL and CRDL (inorganic)
R	Compound analyzed for but not detected	E	Chemical or physical interference during analysis
	Result is unreliable	J	Reported value is estimated
		N	Matrix related interference in the sample
		U	Compound analyzed for but not detected
		V	Slight matrix related interference
		X	Sample specific qualifier
		*	Non-homogeneous sample matrix

ID Insufficient data available to develop criteria
 NS Not Sampled

Result Qualifiers

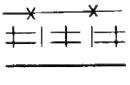
- (1) Results are presented in units of milligrams/liter
- (a) Results are presented in units of micrograms/kilogram
- (b) Criteria does not exist
- (c) Results are presented in units of milligrams/kilogram
- (d) Samples collected during the Site investigation were analyzed for metals by SW846

1

1SB-9	00'-01'
Arsenic	21.40
Lead	17.50
1SB-11	00'-01'
Arsenic	4.10
Lead	19.50
1SS-11	00'-01'
Arsenic	7.10
Lead	9.60
1SB-2	00'-01'
Benzo(a)pyrene	55
Arsenic	1.90
Lead	37.50
1SB-12	00'-01'
Arsenic	5.90
Lead	6.50
1SB-12	00'-01'
Arsenic	8.10
Lead	3150
1SB-19	00'-01'
Arsenic	5.70
Lead	7.70
1SB-3	00'-01'
Benzo(a)pyrene	480
Arsenic	5.60
Lead	52.60
1SS-13	00'-01'
Arsenic	8.50
Lead	8.40
1SS-14	00'-01'
Arsenic	4.80
Lead	10.30

LEGEND

- | | |
|-----|---------------------|
| T | Telephone |
| OHU | Overhead Utilities |
| F | Fire Alarm |
| C | Communication |
| SL | Sanitary Sewer Line |
| S | Storm Drains |
| G | Gas |
| W | Water |



**Above Ground
Storage Tank
(Pre-existing)**

Building with ID Number

Roads

Excavated in 1992

**EXISTING
UNDERGROUND LINE**

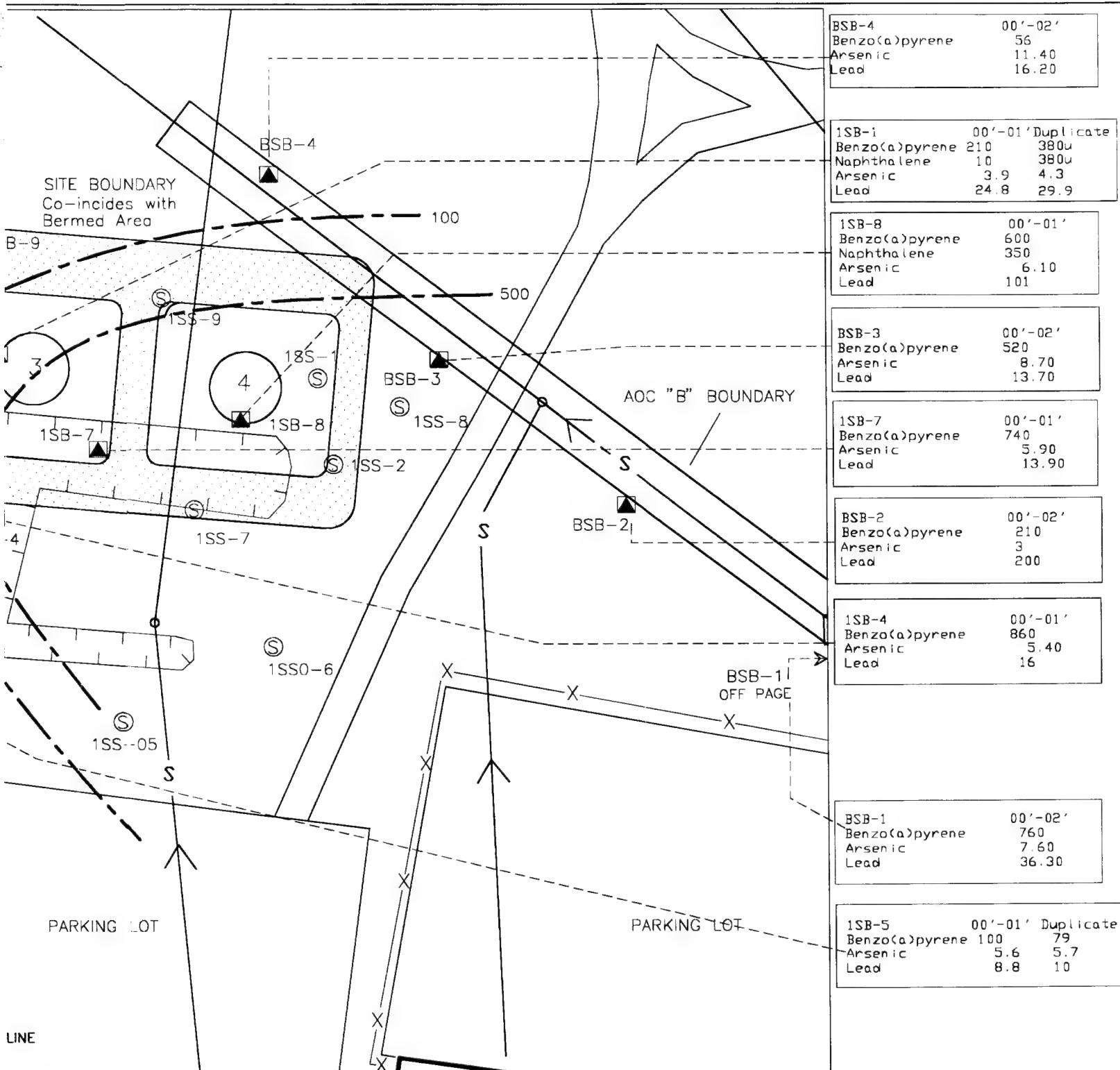
-  Surface Soil Sample Location
 Soil Boring

— Benzo(a) pyrene isoconcentration
Naphthalene = ug/kg
Benzo(a)pyrene = ug/kg
Lead = mg/kg
Arsenic = mg/kg

Note: Surface soil samples results were field screened

Note: All features may not appear on this figure.

(2)



Screening Results

Screening (either PAHs by immunoassay techniques and/or VOCs by GC) results were completed for 26 surface soil locations at Site 1. The AOC B samples were collected in June and July of 1994 and were analyzed for their VOC content using an on-site GC. These results are presented in the Final PA/Site Inspection Report (EARTH TECH, April 1996).

VOC Analysis

No VOCs were detected in surface soil samples 1SB1-0001, 1SB2-0001, or 1SB3-0001.

PAH Analysis

As shown in Appendix B, Table B-1, surface soil PAH screening results range in concentration from <200 to 460,000 ppb. The eastern (around AST 4) and southeastern portions of the site contained PAHs in concentrations exceeding 5,000 ppb. Other samples containing PAHs in excess of 5,000 ppb include 1SS03, 1SS10, and 1SB2-0001. Relatively low concentrations of PAHs (less than 1,000 ppb) were detected in the surface soils west and south of AST 1.

5.3.2.2 Confirmation Results

The surface soil confirmation results are presented in the following subsections.

VOCs

VOCs were analyzed for all confirmation surface soils except sample numbers BC1-SS11 through BC1-SS14. These samples were collected in December 1994 after some of the results of the November soil sampling were available. The November data indicated that VOCs were not chemicals of potential concern in the surface soils. Therefore, VOCs were not analyzed for in the December surface soil samples.

As shown in Table 5-6, only acetone, and PCE were detected in one or more of the surface soils. Methylene chloride detections were qualified "B," indicating blank contamination, and are regarded as being unreliable. Acetone was detected in the surface soil sample collected from locations 1SB8 and 1SB3 in concentrations of 9 and 9 µg/kg, respectively, while PCE was quantified in the surface soil sample collected from location BSB2 at a concentration of 1 µg/kg. No other VOCs were quantified in the Site 1 surface soil data set.

SVOCs

SVOCs, including carcinogenic and non-carcinogenic PAHs, carbazole, dibenzofuran, di-n-butyl phthalate and bis (2-ethylhexyl) phthalate were each detected in one or more of the Site 1 surface soil samples. The frequency and range of detections for these SVOCs are presented in Table 5-7.

Several of the SVOCs, including carbazole, dibenzofuran, bis (2-ethylhexyl) phthalate, and the PAHs, acenaphthene, acenaphthylene, fluorene, 2-methylnaphthalene, and naphthalene were detected relatively infrequently in the surface soils (at least one, but no more than four samples) and in relatively low concentrations (maximum of 373 µg/kg). Di-n-butyl phthalate was detected in 10 samples; each detection was quantified at relatively low concentrations (45 to 100 µg/kg).

The remaining 12 PAHs were detected in at least 7, but no more than 12 samples, in concentrations ranging from 30 to 1,800 µg/kg. The surface distribution of benzo (a) pyrene, one of the carcinogenic PAHs, is shown on Figure 5-7. The distribution of benzo (a) pyrene approximates the distribution of the PAHs as determined by the immunoassay screening. The highest concentrations of benzo (a) pyrene were detected in surface soil samples collected from locations 1SB8 (600 µg/kg), 1SB4 (860 µg/kg), 1SB7 (740 µg/kg) which were all located in the eastern (around AST 4) and southeastern portions of the site. AOC B soil samples also contained benzo (a) pyrene. Benzo (a) pyrene was absent from the area west and south of AST 1. This area did not contain PAH concentrations greater than 1,000 ppb (screening data). The concentrations of the remaining PAHs follow similar trends; samples collected from locations 1SB4, 1SB7, and 1SB8 each contain PAHs in concentrations equal to or in excess

Table 5-7 Frequency and Range of Chemicals Detected in the Site 1/AOC B Surface Soils

	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS			Background
SURFACE SOILS					
ACETONE	2 / 15	9.00	-	9.00	NA
TETRACHLOROETHENE	1 / 15	1.00	-	1.00	NA
2-METHYLNAPHTHALENE	2 / 19	100.00	-	170.00	NA
ACENAPHTHENE	1 / 19	373.00	-	373.00	NA
ACENAPHTHYLENE	3 / 19	48.00	-	65.00	NA
ANTHRACENE	8 / 19	38.00	-	195.00	NA
BENZO(A)ANTHRACENE	11 / 19	42.00	-	930.00	NA
BENZO(A)PYRENE	11 / 19	55.00	-	860.00	NA
BENZO(B)FLUORANTHENE	12 / 19	84.00	-	1600.00	NA
BENZO(G,H,I)PERYLENE	9 / 19	66.00	-	570.00	NA
BENZO(K)FLUORANTHENE	12 / 19	88.00	-	1800.00	NA
CARBAZOLE	4 / 19	39.00	-	98.00	NA
CHRYSENE	12 / 19	52.00	-	850.00	NA
DI-N-BUTYL PHTHALATE	10 / 19	45.00	-	100.00	NA
DIBENZO(A,H)ANTHRACENE	7 / 19	30.00	-	220.00	NA
DIBENZOFURAN	1 / 19	255.00	-	255.00	NA
FLUORANTHENE	12 / 19	58.00	-	1200.00	NA
FLUORENE	4 / 19	38.00	-	192.00	NA
INDENO(1,2,3-CD)PYRENE	9 / 19	70.00	-	540.00	NA
NAPHTHALENE	1 / 19	110.00	-	110.00	NA
PHENANTHRENE	11 / 19	56.00	-	650.00	NA
PYRENE	12 / 19	62.00	-	1100.00	NA
BIS(2-ETHYLHEXYL)PHTHALATE	3 / 19	41.00	-	230.00	NA
ANTIMONY	5 / 19	0.15	-	3.20	0.25
ARSENIC	18 / 19	1.90	-	21.40	7.14
BARIUM	15 / 15	9.60	-	70.60	76.43
BERYLLIUM	18 / 19	0.07	-	0.40	0.19
CADMUM	3 / 19	0.07	-	2.70	1.2
CHROMIUM	19 / 19	4.40	-	58.10	19.10
CHROMIUM, CR + 6	1 / 4	0.02	-	0.02	--
COPPER	19 / 19	5.70	-	24.60	32
LEAD	19 / 19	6.50	-	3150.00	21
MERCURY	0 / 8	--	-	--	--
NICKEL	18 / 19	4.60	-	13.70	20
SELENIUM	6 / 19	0.24	-	1.10	0.59
SILVER	1 / 19	1.90	-	1.90	1.0
THALLIUM	1 / 19	0.31	-	0.31	0.62
ZINC	19 / 19	12.80	-	168.00	47

Organic compounds are presented in units of $\mu\text{g}/\text{kg}$

Inorganic compounds are presented in units of mg/kg

-- Indicates criteria does not exist

NA - Not Applicable

of 1,000 µg/kg, while in the areas west and south of AST 1, surface soils were relatively free of PAHs.

Metals

Metals detected in the Site 1 surface soils include antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, and zinc. The frequency and range of detections for the metals are presented in Table 5-7.

Antimony, cadmium, chromium (+ 6), selenium, silver, and thallium were detected in fewer than 7 of the 19 surface soils collected and analyzed from the site. In contrast, the metals arsenic, barium, beryllium, chromium, copper, lead, nickel, and zinc were detected more frequently (between 15 and 19 of the 19 samples) throughout the data set. Individual metals detected above the higher of the site-specific background or the Type A values include antimony, arsenic, beryllium, cadmium, chromium, lead, selenium, silver, and zinc.

The distribution of arsenic and lead, two of the more prevalent and toxic metals detected at the site, are shown on Figure 5-7. Arsenic was detected in 18 of the 19 samples collected and analyzed at Site 1/AOC B in concentrations ranging from 1.9 to 21.4 mg/kg, while lead was detected in all 19 samples in concentrations ranging from 6.5 to 3,150 mg/kg. Arsenic was detected in seven surface soil samples in concentrations above background (7.14 mg/kg). Samples collected from locations BSB4 (11.4 mg/kg) and 1SB9 (21.4 mg/kg) contained arsenic in concentrations exceeding 10 mg/kg. Both samples are located along the northernmost boundary of the site. The concentration of arsenic in the remaining 16 samples ranged from 1.9 to 8.7 mg/kg.

Lead was detected above its background concentration of 21 mg/kg in surface soil samples collected from locations 1SB1 (27.35 mg/kg), 1SB2 (37.5 mg/kg), 1SB3 (52.6 mg/kg), 1SB8 (101 mg/kg), 1SB12 (3,150 mg/kg), BSB1 (36.3 mg/kg), and BSB2 (200 mg/kg). Lead concentrations above background are limited to the areas around the 4 ASTs, and the southeasternmost portion of AOC B.

Antimony (1 detection above background - 3.2 mg/kg), beryllium (12 detections above background - 0.21 to 0.40 mg/kg), cadmium (1 detection above background - 2.7 mg/kg), chromium (1 detection above background - 58.1 mg/kg), selenium (3 detections above background - 0.60 to 1.1 mg/kg), silver (1 detection above background - 1.9 mg/kg), and zinc (1 detection above background - 168 mg/kg) were also detected in the surface soils above background or Type A values.

5.3.2.3 Subsurface Soil

The analytical results for the immunoassay screening for PAHs and GC analyses for VOCs are included in Appendix B. Samples selected for confirmation analysis are indicated on the data tables presented in Appendix B. The analytical data for the confirmation subsurface soil sampling are presented in Table 5-8. The data presented in Table 5-8 corresponds to the sampling locations shown on Figure 5-8.

Screening Results

Screening (either PAHs by immunoassay techniques and/or VOCs by GC) results were completed for 56 subsurface soil samples obtained from Site 1. The AOC B samples were collected in June and July of 1994 and were analyzed for their VOC content using an on-site GC. These on-site screening results are presented in the Final PA/Site Inspection Report (EARTH TECH, April 1996).

VOC Analysis

The VOCs, ethylbenzene (17 to 210 µg/kg) and xylenes (total - 83 to 1,100 µg/kg) were detected in 3 of the 33 subsurface soil samples. The 20 to 22 ft bgs interval collected from location 1SB2 contained the highest concentration of VOCs in the screening samples. This sample also contained relatively high concentrations of PAHs (8,800 µg/kg).

Table 5-8 Site 1 / Area of Concern B Subsurface Soil Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-1 BC1-B1-05-07	1SB-1 BC1-B1-20-22	1SB-2 BC1-B2-10-12	1SB-2 BC1-B2-20-22	1SB-3 BC1-B3-20-22	1SB-4 BC1-B4-10-12
SAMPLE ID:	1107/94	11/06/94	11/07/94	11/06/94	11/08/94	11/06/94
COLLECTION DATE:	BC-TB2, BC-ER4	BC-TB1, BC-ER5	BC-TB2, BC-ER5	BC-TB1, BC-ER5	BC-TB3, BC-ER6	BC-TB1, BC-ER5
ASSOCIATED QC:	BC-FB3, BC-FB6					
CRITERIA UNITS:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Volatile Compounds by 8240 (a)						
Acetone	7.4E+7	26	17	B	17	
Ethylbenzene	7.2E+7	6	U	6	U	5
Methylene chloride	3.3E+6	11	B	12	B	10
Xylenes (Total)	1.0E+9	17	U	18	U	16
Semivolatile Compounds by 8270 (a)						
2-Methylnaphthalene	5.4E+8	ID	59	U	79	U
Di-n-butyl phthalate	5.4E+8	360	390	U	350	U
Dibenzofuran	ID	360	390	U	350	U
Fluorene	5.4E+8	360	62	U	350	U
Naphthalene	1.6E+8	360	390	U	350	U
Phenanthrene	1.6E+7	360	390	U	350	U
Phenol	4.5E+8	360	390	U	350	U
bis(2-Ethylhexyl)phthalate	1.1E+7	37	0	390	U	350
Metals by CLP (b)(c)						
Antimony	0.36	UJ	0.14	UJ	0.20	UJ
Arsenic	6.57	4.80	4.30	4.10	2.30	4.60
Barium	75	31.10	18.30	0	7.60	9.10
Beryllium	0.08	0.23	0	0.16	0	0.08
Cadmium	1.2	0.03	0	0.04	0.03	0
Chromium	18	11.20	8.60	8.40	4.30	10.30
Copper	32	5.90	7.40	5.70	4.40	9.60
Lead	21	4.40	4.40	7	3.30	5.10
Nickel	20	9.40	19.20	30.60	6.90	27.20
Selenium	0.59	0.30	UJ	0.50	0.30	UJ
Silver	1	0.04	U	0.05	0.04	U
Zinc	47	15.80	J	27.30	J	13.20

Criteria for organic compounds are the NIEPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- (i) Result is between the detection limit and the quantitation limit
- (B) Value is unreliable due to blank contamination value
- (J) Reported value is estimated
- (U) Compound analyzed for but not detected
- (R) Result is unreliable

Laboratory Qualifiers

- (A) Result produced from a single point method-of-standard addition
- (B) Analyte also detected in associated blank (organic)
- (C) Result between IDL and CRDL (inorganic)
- (E) Chemical or physical interference during analysis
- (J) Reported value is estimated
- (N) Matrix related interference in the sample
- (W) Compound analyzed for but not detected
- (X) Slight matrix related interference
- (Y) Sample specific qualifier
- (Z) Non-homogeneous sample matrix

Table 5-8 Site 1 / Area of Concern B Subsurface Soil Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-5 BC1-B5-10-12	1SB-5 BC1-B5-20-22	1SB-7 BC1-B7-10-12	1SB-8 BC1-B8-20-22	1SB-11 BC1-B11-19-23
SAMPLE ID:	7.4E+7 7.2E+7	12 6	B U	29 5	B U
COLLECTION DATE:	11/07/94	11/07/94	11/09/94	11/07/94	11/09/94
ASSOCIATED QC:	BC-TB3, BC-ER5 BC-FB3, BC-FB6	BC-TB2, BC-ER5 BC-FB3, BC-FB6	BC-TB4, BC-ER7 BC-FB3, BC-FB6	BC-TB2, BC-ER5 BC-FB3, BC-FB6	BC-TB4, BC-ER6 BC-FB3, BC-FB6
CRITERIA UNITS:	RESULT	QUAL	RESULT	QUAL	RESULT
Volatile Compounds by 8240 (a)					
Acetone	7.4E+7	12	B	29	B
Ethylbenzene	7.2E+7	6	U	5	U
Methylene chloride	3.3E+6	10	0B	20	B
Xylenes (Total)	1.0E+9	17	U	16	U
Semivolatiles Compounds by 8270 (a)					
2-Methylnaphthalene	ID	370	U	350	U
5,4E+8	46	350	U	60	370
Di-n-butyl phthalate	ID	370	U	350	U
Dibenzofuran				390	370
Fluorene	5,4E+8	370	U	350	370
Naphthalene	1.6E+8	370	U	350	390
Phenanthrene	1.6E+7	370	U	350	390
Phenol	4.5E+8	230	0	350	370
bis(2-Ethylhexyl)phthalate	1.1E+7	370	U	270	0
				390	370
				79	0
				370	370
					1100
Metals by CLP (b)(c)					
Antimony	0.36	U	0.22	U	0.19
Arsenic	6.57	3.80	9.20	5.10	4.40
Barium	75	14.80	0	11	16.70
Beryllium	0.08	0.15	0	0.16	0
Cadmium	1.12	0.03	0.03	0.04	0.04
Chromium	18	6.60	8.70	14	6.50
Copper	32	4.20	5.80	5.60	7.60
Lead	21	3.30	4.70	3	6.60
Nickel	20	5.30	10.50	11.40	10.60
Selenium	0.59	0.32	U	0.28	0.33
Silver	1	0.05	U	0.04	0.05
Zinc	47	11.60	J	13.90	J
				12.40	J
				23.60	J
				18.20	J
				19	J

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- (a) Result is between the detection limit and the quantitation limit
- (b) Value is unreliable due to blank contamination value
- (c) Reported value is estimated
- (d) Compound analyzed for but not detected
- (e) Result is unreliable

Laboratory Qualifiers

- A Result produced from a single point method-of-standard addition
- B Analyte also detected in associated blank (organic)
- C Result between DL and CRDL (inorganic)
- E Chemical or physical interference during analysis
- J Reported value is estimated
- N Matrix related interference in the sample
- U Compound analyzed for but not detected
- W Slight matrix related interference
- X Sample specific qualifier
- * Non-homogeneous sample matrix

ID Insufficient data available to develop criteria
NS Not Sampled
Result Qualifiers
 (a) Results are presented in units of micrograms/kilogram
 (b) Results are presented in units of milligrams/kilogram
 (c) Samples collected during the Site Investigation were analyzed for metals by SWB6

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

Data Validation Qualifiers

- (a) Result is between the detection limit and the quantitation limit
- (b) Value is unreliable due to blank contamination value
- (c) Reported value is estimated
- (d) Compound analyzed for but not detected
- (e) Result is unreliable

Laboratory Qualifiers

- A Result produced from a single point method-of-standard addition
- B Analyte also detected in associated blank (organic)
- C Result between DL and CRDL (inorganic)
- E Chemical or physical interference during analysis
- J Reported value is estimated
- N Matrix related interference in the sample
- U Compound analyzed for but not detected
- W Slight matrix related interference
- X Sample specific qualifier
- * Non-homogeneous sample matrix

Table 5-8 Site 1 / Area of Concern B Subsurface Soil Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	1SB-12	1SB-15	1SB-18	1SB-19	BC1-MW2						
SAMPLE ID:	BC1-B12-20-22	BC1-B15-10-12	BC1-B18-15-17	BC1-B19-20-22	BC1-MW2-20-22						
COLLECTION DATE:	11/07/94	11/08/94	11/09/94	12/14/94	12/14/94						
ASSOCIATED QC:	BC-TB2, BC-ER5 BC-FB3, BC-FB6	BC-TB3, BC-ER6 BC-FB3, BC-FB6	BC-TB4, BC-ER7 BC-FB3, BC-FB6	BC-TB1	BC-TB1						
CRITERIA UNITS:	RESULT	QUAL	RESULT	QUAL	RESULT						
Volatile Compounds by 8240 (a)											
Acetone	7.4E+7	14	B	23	B	7	0B	19	J	10	U
Ethylbenzene	7.2E+7	5	U	6	U	5	U	5	U	5	U
Methylene chloride	3.3E+6	9	0B	14	B	12	B	21	B	22	B
Xylenes (Total)	1.0E+9	15	U	17	U	16	U	17	U	16	U
Semivolatiles Compounds by 8270 (a)											
2-Methylnaphthalene	ID	340	U	370	U	350	U	370	U	350	U
Di-n-butyl phthalate	5.4E+8	340	370	51	0	370	68	0B	35	0B	
Dibenzofuran	ID	340	370	38	0	370	350	U	340	U	
Fluorene	5.4E+8	340	370	350	U	370	350	U	340	U	
Naphthalene	1.6E+8	340	370	350	U	370	350	U	340	U	
Phenanthrene	1.6E+7	340	370	41	0	370	350	U	340	U	
Phenol	4.5E+8	340	370	130	0	370	350	U	340	U	
bis(2-Ethylhexyl)phthalate	1.1E+7	340	88	0	350	U	83	0	350	U	
Metals by CLP (b)(c)											
Antimony	0.36	0.12	UJ	0.13	UJ	1.30	0J	0.14	UJ	0.20	UJ
Arsenic	6.57	1.80		3.50		16.20		1.20		3.80	13.90
Barium	75	4.60	0	15.80	0	68.70	0	7.90	0	10.30	0
Beryllium	0.08	0.05	0	0.10	0	0.11	0	0.10	0	0.12	0
Cadmium	1.2	0.03	U	0.03	U	0.22	0	0.03	U	0.05	U
Chromium	18	3.40		5		275		4.90		5.20	3.40
Copper	32	2.80		3.20		23.10		3.20		4.30	5.20
Lead	21	2.30		3		6.70		2.20		3.80	J
Nickel	20	15.80		4.20	0	39.20		12.20		4.80	4.80
Selenium	0.59	0.28	UJ	0.31	UJ	0.30	UJ	0.32	UJ	0.65	0.73
Silver	1	0.04	U	0.04	U	0.06	0	0.16	0	0.06	UJ
Zinc	47	11.30	J	12.20	J	21.20	J	10.10	J	15.50	8.50

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(a) Results are presented in units of micrograms/kilogram

(b) Results are presented in units of milligrams/kilogram

(c) Samples collected during the Site investigation were analyzed for metals by SW846

Data Validation Qualifiers

(I) Result is between the detection limit and the quantitation limit

(B) Value is unreliable due to blank contamination value

(J) Reported value is estimated

(R) Compound analyzed for but not detected

(W) Slight matrix related interference

(X) Sample specific qualifier

Laboratory Qualifiers

(A) Result produced from a single point method-of-standard addition

(B) Analyte also detected in associated blank (organic)

(C) Result between IDL and CRDL (inorganic)

(E) Chemical or physical interference during analysis

(N) Matrix related interference in the sample

(U) Compound analyzed for but not detected

(V) Non-homogeneous sample matrix

Table 5-8 Site 1 / Area of Concern B Subsurface Soil Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BSB-1 BCB-B1-2527	BSB-2 BCB-B2-2022	BSB-3 BCB-B3-1011	BSB-4 BCB-B4-0507	BSB-4 BCB-B4-1012	BSB-4 BCB-B4-101D
SAMPLE ID:	07/13/94	07/13/94	07/13/94	07/13/94	07/13/94	07/13/94
COLLECTION DATE:						
ASSOCIATED QC:						
CRITERIA UNITS:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Volatile Compounds by 8240 (a)						
Acetone	7.4E+7	32	B	27	B	24
Ethylbenzene	7.2E+7	11	U	10	U	10
Methylene chloride	3.3E+6	9	JB	7	JB	8
Xylenes (Total)	1.0E+9	11	U	10	U	10
Semivolatiles Compounds by 8270 (a)						
2-Methylnaphthalene	5.4E+8	ID	340	U	340	U
Di-n-butyl phthalate	5.4E+8	45	J	48	J	48
Dibenzofuran	5.4E+8	ID	340	U	340	U
Fluorene	5.4E+8	340	U	340	U	340
Naphthalene	1.6E+8	340	U	340	U	340
Phenanthrene	1.6E+7	340	U	340	U	340
Phenol	4.5E+8	340	U	340	U	340
bis(2-Ethylhexyl)phthalate	1.1E+7	340	U	340	U	340
Metals by CLP (b)(c)						
Antimony	0.36	3.20	UN	3.50	N	3.80
Arsenic	6.57	2	N	5.30	N	12.70
Barium	75	-	-	-	-	-
Beryllium	0.08	0.12	U	0.12	B	0.13
Cadmium	1.2	0.36	UN	0.35	UN	0.35
Chromium	18	3.30	N	8.50	N	8
Copper	32	2.50	B	6.40	6.80	4.40
Lead	21	2.20	A*	3.40	*	6.50
Mercury		0.10	U	0.10	U	4.50
Nickel	20	4.20	U	15.10	U	10.90
Selenium	0.59	0.41	UWN	0.40	UWN	0.40
Silver	1	0.42	U	0.41	U	0.41
Zinc	47	12.80	EN	17.80	EN	29.90

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(a) Results are presented in units of micrograms/kilogram

(b) Results are presented in units of milligrams/kilogram

(c) Samples collected during the Site Investigation were analyzed for metals by SWB46

Data Validation Qualifiers

(I) Result is between the detection limit and the quantitation limit

(B) Value is unreliable due to blank contamination value

(J) Reported value is estimated

(R) Compound analyzed for but not detected

(U) Result is unreliable

Laboratory Qualifiers

(A) Result produced from a single point method-of-standard addition

(B) Analyte also detected in associated blank (organic)

(C) Result between IDL and CRDL (inorganic)

(E) Chemical or physical interference during analysis

(J) Reported value is estimated

(N) Matrix related interference in the sample

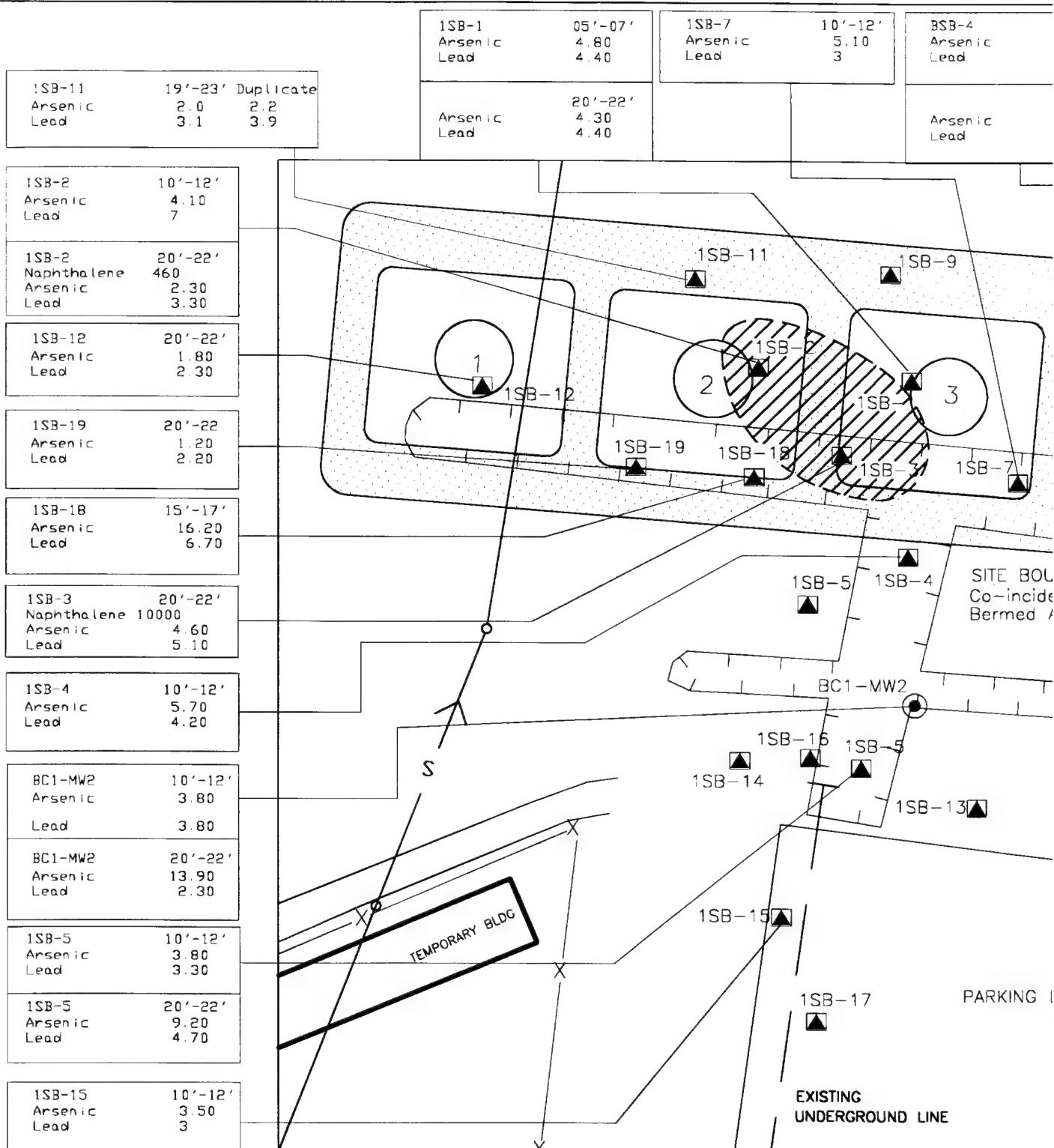
(U) Compound analyzed for but not detected

(W) Slight matrix related interference

(X) Sample specific qualifier

(*) Non-homogeneous sample matrix

①



LEGEND

- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- S Storm Drains
- G Gas
- W Water



Fence
Railroad
Stream



Above Ground
Storage Tank
(Pre-existing)



Building with ID Number



Roads



Excavated in 1992



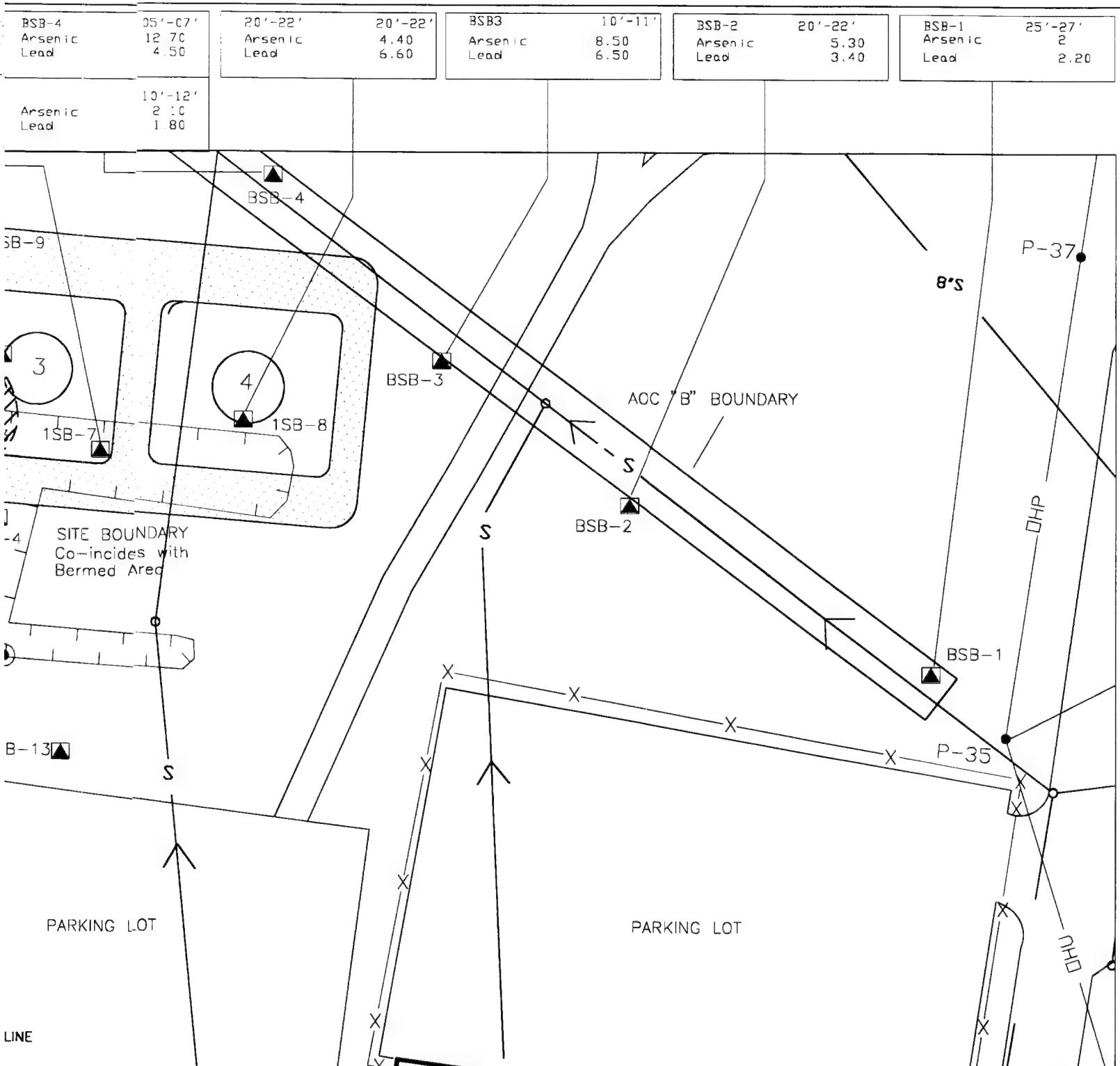
Water Table Monitor
Soil Boring



Naphthalene = ug/
Arsenic = mg/kg
Lead = mg/kg

Note: Soil boring results were field

(2)



EARTHTECH

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 1
SUBSURFACE SOIL LOCATIONS
AND RESULTS FOR
NAPHTHALENE, ARSENIC AND LEAD**

6/95

FIGURE 5-8

5-39

PAH Analysis

Subsurface soils were collected at 5 ft intervals from the ground surface to the water table from borings 1SB1 through 1SB5, 1SB7 through 1SB9, 1SB11, 1SB12, 1SB18, 1SB19, and BC1-MW2. Borings 1SB6, and 1SB13 through 1SB17 were sampled only at the 10 to 12 ft bgs interval. Fifty-six subsurface samples (excluding duplicates) were collected from these borings and analyzed for their PAH content by immunoassay techniques.

Ten subsurface soil samples contained PAHs above 1,000 ppb. Eight of these 10 samples were submitted for confirmation analysis. The 25 to 27 ft interval collected from location 1SB5 (>5,000 ppb-not confirmed) was wet and is indicative of the presence of PAHs in the groundwater rather than in the soils. The 10 to 12 ft sample collected from 1SB9 contained PAHs at 1,100 ppb. This sample was also not confirmed. The remaining detections of PAHs above 1,000 ppb were all quantified from around AST 2. These samples were all collected from locations 1SB2, 1SB3, 1SB9, 1SB18, and 1SB19. All detections above 1,000 ppb were quantified in samples collected from depths within the soil column greater than 10 ft bgs. The highest concentration of PAHs (230,000 ppb) were detected in the 20 to 22 ft bgs sample from 1SB3.

5.3.2.4 Confirmation Results

The subsurface soil confirmation results are presented in the following subsections.

VOCs

VOCs were analyzed for all confirmation subsurface soils obtained for Site 1/AOC B. As shown in Table 5-8, only acetone, ethylbenzene, and xylenes (total) were detected in one or more of the subsurface soils. All of the methylene chloride was qualified "B" indicating blank contamination and are regarded as being unreliable. Acetone was detected in the subsurface soil samples collected from locations 1SB1, 1SB2, and BC1-MW2 in concentrations of 26, 17, and 19 µg/kg, respectively. Ethylbenzene and xylenes (total) were quantified in the 20 to 22 ft bgs interval from 1SB3. The relatively high concentrations of ethylbenzene and xylenes detected in the screening data (GC only) from this sample were not confirmed by the GC/Mass

Spectroscopy confirmation analysis. No other VOCs were quantified in the Site 1/AOC B subsurface soil data set.

SVOCs

SVOCs, including non-carcinogenic PAHs, dibenzofuran, phenol, di-n-butyl phthalate, and bis (2-ethylhexyl) phthalate, were each detected in one or more of the Site 1/AOC B subsurface soil samples. The frequency and range of detections for the individual SVOCs are presented in Table 5-9.

**Table 5-9 Frequency and Range of Detections - Subsurface Soils - Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan**

	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS			Background
SUBSURFACE SOILS					
ACETONE	3 / 22	17.00	-	26.00	NA
ETHYLBENZENE	1 / 22	3.00	-	3.00	NA
XYLEMES (TOTAL)	1 / 22	5.00	-	5.00	NA
2-METHYLNAPHTHALENE	4 / 22	59.00	-	74000.00	NA
DI-N-BUTYL PHTHALATE	6 / 22	45.00	-	60.00	NA
DIBENZOFURAN	1 / 22	38.00	-	38.00	NA
FLUORENE	2 / 22	62.00	-	6600.00	NA
NAPHTHALENE	2 / 22	460.00	-	10000.00	NA
PHENANTHRENE	3 / 22	41.00	-	9900.00	NA
PHENOL	2 / 22	130.00	-	230.00	NA
BIS(2-ETHYLHEXYL)PHTHALATE	9 / 22	37.00	-	1100.00	NA
ANTIMONY ^(a)	8 / 22	0.19	-	4.70	0.36
ARSENIC	22 / 22	1.20	-	16.20	6.57
BARIUM	17 / 17	4.60	-	68.70	75
BERYLLIUM	20 / 22	0.05	-	0.23	0.08
CADMIUM	2 / 22	0.08	-	0.22	1.2
CHROMIUM	22 / 22	3.30	-	275.00	18
COPPER	22 / 22	2.50	-	23.10	32
LEAD	22 / 22	1.80	-	7.00	21
MERCURY	0 / 5	--	-	--	--
NICKEL	21 / 22	4.20	-	39.20	6.52
SELENIUM	3 / 22	0.50	-	0.73	0.41
SILVER	3 / 22	0.06	-	0.16	1.0
THALLIUM	0 / 22	--	-	--	--
ZINC	22 / 22	8.50	-	29.90	47

Organic compounds are presented in units of $\mu\text{g}/\text{kg}$

Inorganic compounds are presented in units of mg/kg

-- Indicates criteria does not exist

NA Not Applicable

Dibenzofuran was detected in the 15 to 17 ft bgs sample from 1SB18 at a concentration of 38 $\mu\text{g}/\text{kg}$. Di-n-butyl phthalate and bis (2-ethylhexyl) phthalate were detected in six and nine

samples, respectively. Phenol was quantified in relatively low concentrations (230 and 130 µg/kg) in the 10 to 12 ft bgs sample obtained from 1SB5 and from the 15 to 17 ft bgs sample from 1SB18. Each of these borings are located along the pre-existing east-west trending fuel line located immediately south of the ASTs. The PAHs fluorene (2 detections - 62 and 6,600 µg/kg), 2-methylnaphthalene (4 detections - 59 to 74,000 µg/kg), naphthalene (2 detections - 460 and 10,000 µg/kg), and phenanthrene (3 detections - 41 to 9,900 µg/kg) were also quantified in the subsurface soils. Individual PAH detections which exceed 1,000 µg/kg were found only in the 20 to 22 ft bgs sample collected from location 1SB2 (2-methylnaphthalene - 2,000 µg/kg) and the 20 to 22 ft bgs sample collected from location 1SB3 (2-methylnaphthalene - 74,000 µg/kg, fluorene - 6,600 µg/kg, naphthalene - 10,000 µg/kg, and phenanthrene - 9,900 µg/kg).

Metals

Metals detected in the Site 1 subsurface soils include antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc. The frequency and range of detections for the metals are presented in Table 5-9. Of these 12 metals, antimony (4 detections above background (1.3 to 4.7 mg/kg), arsenic (5 detections above background - 8.5 to 16.2 mg/kg), beryllium (15 detections - 0.09 to 0.23 mg/kg), chromium (3 detections above background - 48.4 to 275 mg/kg), nickel (4 detections above background - 21.5 to 39.2 mg/kg), and selenium (2 detections above background - 0.65 to 0.73 mg/kg) were quantified in concentrations which exceed their respective background concentrations.

The distribution of arsenic and lead in the Site 1/AOC B subsurface soils is presented on Figure 5-8. Lead concentrations are relatively low when compared to the surface soil values. Lead concentrations are relatively uniform across the site, ranging from 1.8 to 7 mg/kg. Arsenic was detected above background in samples collected from locations 1SB5 and BC1-MW2 (located along the north-south trending fuel line), locations BSB3 and BSB4, and from location 1SB18. The 15 to 17 ft bgs sample collected from 1SB18 contained four metals (antimony, arsenic, chromium, and nickel) in concentrations above background.

5.3.3 Site 1 Groundwater Analytical Results

Site 1 groundwater analytical results are presented in the following subsections. A separate discussion of screening versus confirmation results will not be presented for the groundwater samples because the groundwater "screening" analyses were completed using EPA SW846 methods in an off-site laboratory. These analyses are of similar quality to the confirmation analyses. A majority of these samples were collected using Geoprobe® sampling methods, and all were collected under HAZWRAP Level "B" field QA protocols. Twenty-one groundwater screening samples (19 Geoprobe® samples and 2 from the existing monitoring wells) were collected during the field event. The analytical results for these samples are included in Appendix B, Table B-2, while the confirmation analytical results are presented in Table 5-10. The groundwater analytical data are presented graphically on Figure 5-9.

Screening sample 1GW6, located in the south-central portion of the site contained a thin film or sheen of free-phase product which separated out in the sample bottles after the samples were collected. Well BC1-MW2 was installed at this location as a water table well and monitored to establish the presence or absence of free-phase product during the winter of 1994-1995. A hydrocarbon-water interface probe was used on four separate occasions (see Figure 5-9) to determine the presence of a free-phase layer of hydrocarbons. No free-phase hydrocarbon layer was detected during each of the four rounds of measurements. Groundwater samples were collected from the water table and at a depth approximately 10 ft below the water table from locations 1GW1 and 1GW10 and from three depths separated by a vertical distance of 15 ft at location 1GW13. These samples were collected at the down-gradient, or leading edge of the dissolved groundwater plume. In addition, vertical profiling was completed at locations 1GW3, 1GW14/BC1TMW3, and 1GW6/1GW12. These samples are located within the main portion of the dissolved groundwater plume.

VOC Analytical Results

Twelve individual VOCs were detected in the groundwater screening samples obtained from the surficial aquifer beneath Site 1. Of the 21 samples collected, only samples 1GW1 (water table), 1GW3, 1GW6, 1GW10 (water table), BC1TMW3, and 1GW14 contained VOCs. VOCs detected in this data set which exceed the NREPA PA 451 residential health-based criteria are

Table 5-10 Site 1 Groundwater Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC1-MW1	BC1-MW1	BC1-MW3	BC2-MW1	BC2-MW1	BC1-MW2(a)
SAMPLE ID:	BC1-MW1-GW5	BC1-MW1-GW5D	BC1-MW3-GW5	BC2-MW1-GW4	BC2-MW1-GW5	BC1-MW2-GW6
COLLECTION DATE:	12/18/94	12/18/94	12/18/94	05/23/94	12/17/94	5/17/95
ASSOCIATED QC:	BC-TB2	BC-TB2	BC-TB5	BC-TB5, BC-ER1	BC-TB2,	--
	BC-FB1	BC-FB2	BC-FB1	BC-FB1, BC-FB2, BC-FB3	BC-FB1	--
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (b)						
Methylene chloride	5	1.20	B	0.02	0B	1.40
Aromatic Volatiles Compounds by 8020 (b)						
1,3-Dichlorobenzene	600	0.20	U	0.20	U	0.46
1,4-Dichlorobenzene	75	0.15	U	0.15	U	0.29
Benzene	5	0.35	U	0.35	U	0.05
Ethylbenzene	700	0.20	U	0.20	U	1
Toluene	1000	0.25	U	0.25	U	J
m-Xylene	10000(c)	0.5	U	0.18	U	0.25
p-Xylene	10000(c)	0.5	U	0.18	U	0.20
Semivolatile Compounds by CLP (b)						
2-Methylnaphthalene	ID	5	U	5	U	5
Di-n-butyl phthalate	880	0.50	0	0.80	5	2
Naphthalene	260	5	U	5	5	B
Acenaphthene	1300	5	U	5	10	U
Fluorene	880	5	U	5	10	U
Phenanthrene	26	5	U	5	10	U
Metals by CLP (b)(d)						
Aluminum	62.2	NA	NA	NA	129	0B
Arsenic	50	2.20	U	2.20	U	2.60
Barium	2000	84	0	85.60	0	39.90
Calcium	73850	NA	NA	NA	76700	0B
Cobalt	37	NA	NA	NA	6.30	U
Copper	1400	3.70	0	5.60	0	4.50
Iron	356	NA	NA	NA	10.60	U
Lead	4	2.30	0	1.60	U	4.30
Magnesium	14973	NA	NA	NA	19800	UJ
Manganese	807	NA	NA	NA	246	NA
Nickel	100	1.60	0	1.50	U	38.80
Potassium	1839	NA	NA	NA	2309.30	U

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA 451 residential drinking water values.

ID Insufficient data available to develop criteria
 NA Not analyzed for

Result Qualifiers

- (a) Analyzed by EARTH TECH Laboratory Services, Grand Rapids, Michigan; all other samples analyzed by CompuChem Laboratory, North Carolina
- (b) Results are presented in units of micrograms/liter
- (c) Total Xylenes
- (d) Samples collected during the Site Investigation were analyzed for metals
- (e) Results are presented in units of milligrams/liter
- (f) Aesthetic drinking water criteria for chloride and sulfate are 250 milligrams/liter
- (g) Criteria does not exist

Data Validation Qualifiers

- (i) Result is between the detection limit and the quantitation limit
- (j) Value is unreliable due to blank contamination value
- (k) Reported value is estimated
- (l) Compound analyzed for but not detected
- (m) Result is unreliable

Table 5-10 Site 1 Groundwater Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan									
LOCATOR:	BC1-MW1	BC1-MW1	BC1-MW3	BC2-MW1	BC2-MW1	BC1-MW2(a)			
SAMPLE ID:	BC1-MW1-GW5	BC1-MW1-GW5D	BC1-MW3-GW5	BC2-MW1-GW4	BC2-MW1-GW5	BC1-MW2-GW6			
COLLECTION DATE:	12/18/94	12/18/94	12/18/94	05/23/94	12/17/94	05/17/95			
ASSOCIATED QC:	BC-TB2	BC-TB2	BC-TB5	BC-TB5, BC-ER1	BC-TB2,	--			
	BC-FB1	BC-FB1, BCFB2	BC-FB1	BC-FB1, BC-FB2, BC-FB3	BC-FB1	--			
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL	RESULT
Sodium	160000	NA	NA	NA	21100	U	NA	NA	NA
Vanadium	64	NA	NA	NA	5.30	U	NA	NA	NA
Zinc	2400	0.69	()	2.20	()	11.60	()	8.50	0
<i>Water Quality Parameters (e)</i>									
Chloride	ID(f)	NA	NA	NA	37.9	NA	NA	NA	NA
Sulfate	ID(f)	NA	NA	NA	13.2	NA	NA	NA	NA
Dissolved Solids	(g)	NA	NA	NA	360	NA	NA	NA	NA
Nitrate	10	NA	NA	NA	0.3	NA	NA	NA	NA

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA 451 residential drinking water values.

ID Insufficient data available to develop criteria

NA Not analyzed for

Data Validation Qualifiers

I Result is between the detection limit and the quantitation limit

B Value is unreliable due to blank contamination value

J Reported value is estimated

U Compound analyzed for but not detected

R Result is unreliable

Total Xylenes

Results are presented in units of milligrams/liter

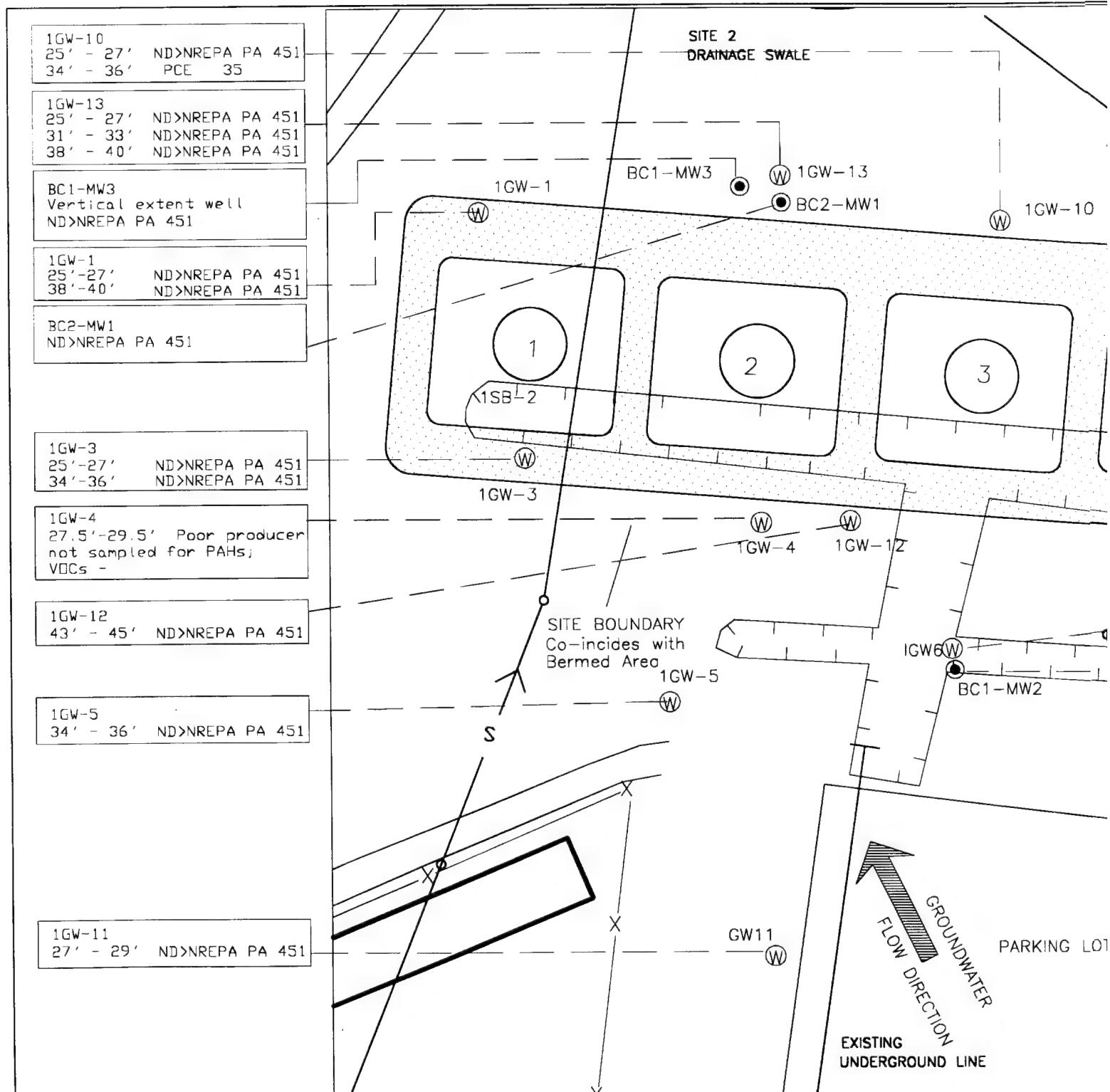
Samples collected during the Site Investigation were analyzed for metals

Results are presented in units of milligrams/liter

Aesthetic drinking water criteria for chloride and sulfate are 250 milligrams/liter

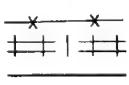
Criteria does not exist

(1)

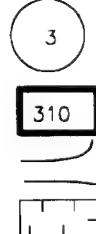
**LEGEND**

- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- S Storm Drains
- G Gas
- W Water

Note: All features may not appear on this figure.



Fence
Railroad
Stream



Above Ground
Storage Tank
(Pre-existing)

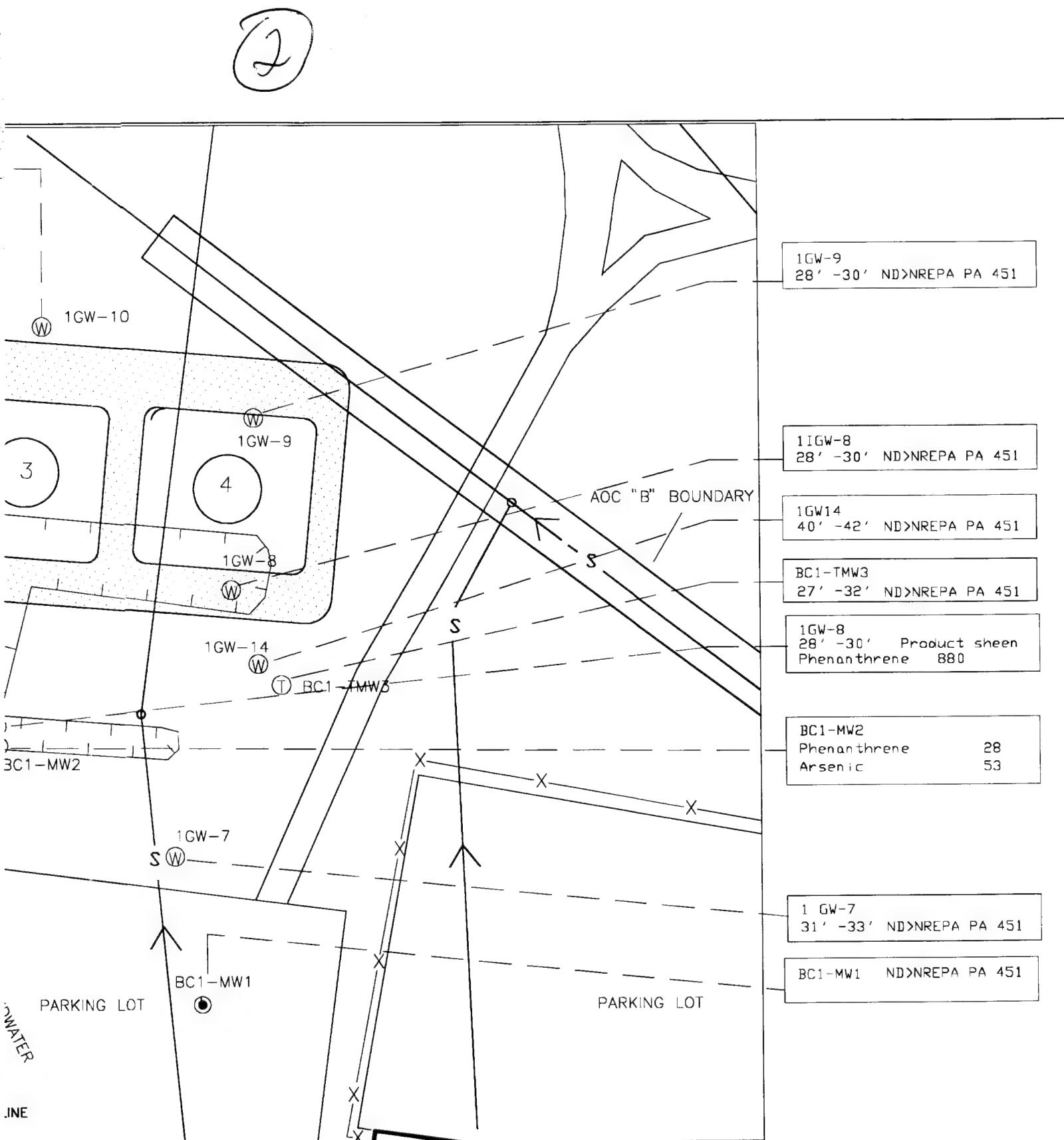
Building with ID Number

Roads

Excavated in 1992

KEY TO SAMPLING SYMBOLS

- (●) Water Table Monitoring Well
- (T) Temporary Monitoring Well
- (W) Groundwater Screening Location
- (—) All Concentrations Present
- ND>NREPA PA 451 = No greater than the NREPA PA 451 based drinking water value



TO SAMPLING SYMBOLS:

W Table Monitoring Well

SW Temporary Monitoring Well

WATER Screening Location

Concentrations Presented in ug/l

A PA 451 = No detection
on the NREPA PA 451 residential health-
risk water value

0 50 100 Feet

Scale 1"=50'



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 1 GROUNDWATER SAMPLING LOCATIONS AND RESULTS

presented on Figure 5-9. Along the down-gradient (northern) edge of the site, PCE (35 $\mu\text{g/l}$) in 1GW10 (34 to 36 ft bgs) was detected above the NREPA PA 451 residential health-based criteria. PCE was also detected in 1GW14 (40 to 42 ft bgs) and BC1TMW3 (27 to 32 ft bgs) in concentrations of 4.45 and 2.4 $\mu\text{g/l}$, respectively; these concentrations are below the NREPA PA 451 residential health-based drinking water values. No other VOCs were detected in concentrations exceeding the NREPA PA 451 residential health-based criteria.

Confirmation samples were collected in May 1994 from well BC2-MW1 and in December 1994 from wells BC1-MW1, BC1-MW3, and BC2-MW1. Well BC1-MW2, which was monitored through the winter for the presence of free-phase product, was sampled during May 1995. Methylene chloride, 1,3- and 1,4- dichlorobenzene, and the BTEX compounds were detected in these samples. Groundwater samples collected from BC1-MW2 were free of VOCs. No VOC detection was quantified in a concentration which exceeds the NREPA PA 451 residential health-based criteria.

SVOCs

1-, and 2- Methylnaphthalene, naphthalene, fluorene, and phenanthrene were detected in one or more of the groundwater screening samples collected from Site 1. SVOCs detected in this data set which exceed the NREPA PA 451 residential health-based criteria are presented on Figure 5-9. Although present in samples 1GW6 (water table), 1GW10 (water table), 1GW12 (45 to 47 ft bgs), 1GW13 (water table), and BC2-MW1, only sample 1GW6 contained a SVOC at a concentration which exceeded the NREPA PA 451 residential health-based criteria. Phenanthrene was quantified in this sample at a concentration of 880 $\mu\text{g/l}$, which exceeds the NREPA PA 451 residential health-based criteria of 25 $\mu\text{g/l}$.

Confirmation samples were collected from wells BC2-MW1, BC1-MW1, BC1-MW3, and BC1-MW2. The PAHs acenaphthene, fluorene, phenanthrene, 2-methylnaphthalene, naphthalene, and di-n-butyl phthalate were detected in the groundwater samples. Only phenanthrene, quantified in a concentration of 28 $\mu\text{g/l}$ was detected at a concentration exceeding the NREPA PA 451 residential health-based criteria.

Metals

Confirmation samples were collected from wells BC2-MW1, BC1-MW1, BC1-MW3, and BC1-MW2. The metals concentrations above either the higher value between background or the NREPA PA 451 residential health-based criteria are presented on Figure 5-9.

In May 1994, well BC2-MW1 was analyzed for Target Analyte List (TAL) metals (filtered) as part of the base boundary sampling. The remaining Site 1 wells were sampled for PP metals plus barium (filtered) during December 1994 and May 1995. Only arsenic (53 µg/l) was detected in the groundwater sample collected from BC1-MW2 at a concentration above either the higher of the background or NREPA PA 451 residential health-based criteria.

5.3.4 Site 1 - Discussion of Results

A brief discussion and interpretation of the analytical results is presented in the following subsections.

Surface Soil Results

The Site 1/AOC B surface soils contain SVOCs and metals, particularly arsenic and lead. There are three potential origins for the presence of these compounds in the surface soils:

- Release(s) of heating oil from the ASTs
- Coal particles transported from Site 5
- Sandblasting and painting operations completed on or around the ASTs.

A release(s) of heating oil from the ASTs would account for the presence of the PAHs, but would not explain the high metals concentrations. The presence of coal particles, transported from Site 5, The Coal Storage Area, or the presence of paint chips would assist in explaining the presence of the arsenic, lead, and other metals in the soils. The analytical results suggest that construction activities completed in the early 1990s (excavation of the pipelines and leveling of the berms) have redistributed the surface soils and may explain why portions of Site 1 (between ASTs 1 and 2 and south of AST 1) are relatively free of PAHs and metals.

Subsurface Soil Results

Subsurface soils containing hydrocarbons appear to be limited to an area between former ASTs 2 and 3. Naphthalene and other PAHs were detected within the subsurface soils at relatively high concentrations (maximum concentration of 10,000 µg/kg). These hydrocarbons are probably due to the release of heating oil from the former ASTs. The presence of hydrocarbons in the groundwater up-gradient from this location suggests that a separate release occurred along the length of the north-south trending fuel line. No PAHs were detected in subsurface soils collected from locations where the old fuel line used to run. The absence of hydrocarbons in these soils suggests that if a release had in the past occurred from the line, these hydrocarbons have migrated through the vadose zone soils to the groundwater. Infiltrating precipitation could have flushed the fuel from the porous sandy soils beneath the line. This process would explain why the soil samples collected from borings 1SB4, 1SB5, and BC1-MW2 do not contain hydrocarbons, but there is evidence that a release (groundwater analytical results obtained from BC1-MW2) has occurred in this portion of the site.

Groundwater Analytical Results

The groundwater analytical results have shown that an area beneath Site 1 has been impacted by hydrocarbons which have originated from a release of heating oil, or other hydrocarbons rich in PAHs. Based on the data presented in this report, a free-phase layer of hydrocarbons is not present on top of the groundwater. Groundwater is being monitored at the suspected point of release, up-gradient of the suspected point of release, and down-gradient (both at the water table and approximately 15 to 20 ft below the water table) of the suspected point of release. One groundwater confirmation sample contained phenanthrene (28 µg/l) and arsenic (53 µg/l) in excess of their respective NREPA PA 451 residential health-based drinking water criteria. Based on the screening data, groundwater containing the one PAH in excess of the NREPA PA 451 residential health-based drinking water criteria has not migrated past the northern boundary of Site 1. The PCE and benzene detected in the groundwater screening samples are not suspected to have originated from the hydrocarbon (heating oil) release, because the groundwater sample collected from BC1-MW2 (suspected of containing free-phase product) was free of VOCs.

5.4 SITE 3 - FIRE TRAINING AREA

The following investigation activities were performed at Site 3:

- Six surface and subsurface soil samples were collected and submitted to an analytical laboratory for analysis of PP metals plus barium.
- Six groundwater samples were collected from six existing monitoring wells (BC3-MWI through BC3-MW6) and shipped to an analytical laboratory for analyses of VOCs, SVOCs, and PP metals plus barium.

5.4.1 Site Geology and Hydrogeology

The Site 3 geology and hydrogeology are briefly described in the following sections. Figure 5-3 presented the December 1994 groundwater elevation map for the base (including Site 3). Portions of Site 3 were contained on the base-wide cross section (Figure 3-5).

Geology

The glacial drift beneath Site 3 consists primarily of fine- to coarse-grained quartz sand, which contains varying amounts of clay, silt, and/or gravel layers. The descriptions of the glacial drift were obtained from field observations obtained during the drilling and sampling operations and from the Engineering Science, Final SI Report (November, 1993).

Hydrogeology

The groundwater contained in the glacial aquifer beneath Site 3 occurs at a relatively uniform depth of approximately 28 ft bgs. Groundwater flow beneath the site is to the north-northwest at an average hydraulic gradient of 0.005. As is shown on Figures 5-2 and 5-3, well BC3-MW1 is located up-gradient of Site 3, while BC3-MW2 was installed on the west side of the berm. Wells BC3-MW3, BC3-MW4, BC3-MW5, and BC3-MW6 were installed down-gradient of the bermed area.

The calculated hydraulic conductivity for the surficial aquifer beneath Site 3 averages 1.4×10^{-2} cm/sec (39 ft/day). These data were obtained from the slug-testing results for well BC3-MW1, -MW2, and -MW3, which were reported by Engineering Science (1993). The groundwater velocity (v) beneath Site 3 is 204 ft/yr (0.56 ft/day) which was calculated using the following equation (Freeze and Cherry, 1979):

$$v = \frac{k}{n} \times \frac{dh}{dl}$$

where:

k = hydraulic conductivity

n = porosity (assumed to be 35% for unconsolidated glacial drift)

$\frac{dh}{dl}$ = hydraulic gradient

5.4.2 Site 3 Soil Analytical Results

The confirmation surface and subsurface soil analytical results are presented in Tables 5-11 and 5-12, respectively. The confirmation surface soil and soil boring locations are presented on Figure 5-10. Each soil sample was analyzed for PP metals plus barium. The concentration of a particular analyte was averaged when a sample and a field duplicate sample are presented in the data set. One-half of the detection limit was used in the calculation if a particular analyte was not detected in either the sample or the field duplicate.

5.4.2.1 Surface Soil

Surface soil analytical results are presented in Table 5-11. The metals antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, and zinc were detected in one or more of the surface soils. Antimony (3 detections above background 0.36 to 0.72 mg/kg), barium (1 detection above background; 102 mg/kg), cadmium [4 detections (3 samples plus one field duplicate result) above background; 1.8 to 8.6 mg/kg], chromium (2 detections above background; 26.8 to 61.9 mg/kg), lead [4 detections (3 samples plus one field duplicate result) above background; 244 to 609 mg/kg], and zinc (4 detections (3 samples plus one field duplicate result) above background; 62.3 to 649 mg/kg) were the

Table 5-11 Site 3 Surface Soil Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	3SB-1 BC3-SB101	3SB-2 BC3-SB201	3SB-2 BC3-SB201D	3SB-3 BC3-SB301
SAMPLE ID:	11/05/94 BC-TB1, BC-ER3 BC-FB3, BC-FB6	11/05/94 BC-TB1, BC-ER3 BC-FB3, BC-FB6	11/05/94 BC-TB1, BC-ER3 BC-FB3, BC-FB6	11/05/94 BC-TB1, BC-ER3 BC-FB3, BC-FB6
COLLECTION DATE:				
ASSOCIATED QC:				
CRITERIA:	RESULT	QUAL	RESULT	QUAL
Metals by CLP (a)(b)				
Antimony	0.25	0.14	0.36	0.4
Arsenic	7.14	3	3.70	4.6
Barium	76.43	21.70	22.50	20.4
Beryllium	0.19	0.13	0.12	0.11
Cadmium	1.2	2.20	2.20	1.80
Chromium	19.1	9.90	27.40	26.8
Copper	32	20.30	19.40	14.1
Lead	21	356	244	261
Nickel	20	5.20	7.20	5.9
Silver	1.0	0.08	0.09	0.09
Zinc	47	62.30	649	72.3

Criteria for organic compounds are the NREPA PA 451 Industrial direct contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(a) Results are presented in units of milligrams/kilogram
 (b) Samples collected during the Site Investigation were analyzed for metals by SW846

Data Validation Qualifiers
 J Result is between the detection limit and the quantitation limit
 B Value is unreliable due to blank contamination value
 R Reported value is estimated
 U Compound analyzed for but not detected
 R Result is unreliable

Table 5-12 Site 3 Subsurface Soil Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	3SB-1	3SB-2	3SB-3
SAMPLE ID:	BC3-B1-04-06	BC3-B2-04-06	BC3-B3-04-06
COLLECTION DATE:	11/08/94	11/08/94	11/08/94
ASSOCIATED QC:	BC-TB1, BC-ER3	BC-TB1, BC-ER3	BC-TB1, BC-ER3
	BC-FB3, BC-FB6	BC-FB3, BC-FB6	BC-FB3, BC-FB6
CRITERIA:	RESULT	QUAL	RESULT
	RESULT	QUAL	RESULT
Metals by CLP (a)(b)			QUAL
Antimony	0.36	0.21	UJ
Arsenic	6.57	5.60	J
Barium	75	6.40	0
Beryllium	0.08	0.10	0
Cadmium	1.2	0.16	0
Chromium	18	5.20	J
Copper	32	5.70	J
Lead	21	5.20	J
Nickel	20	5.80	J
Silver	1.0	0.50	U
Zinc	47	11.70	U
			12.70

Criteria for organic compounds are the NREPA PA 451 Industrial direct Contact values; for inorganic compounds criteria are the highest of the background or Type A default values.

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

(a) Results are presented in units of milligrams/kilogram
 (b) Samples collected during the Site Investigation were analyzed for metals by SW846

Data Validation Qualifiers

0 Result is between the detection limit and the quantitation limit

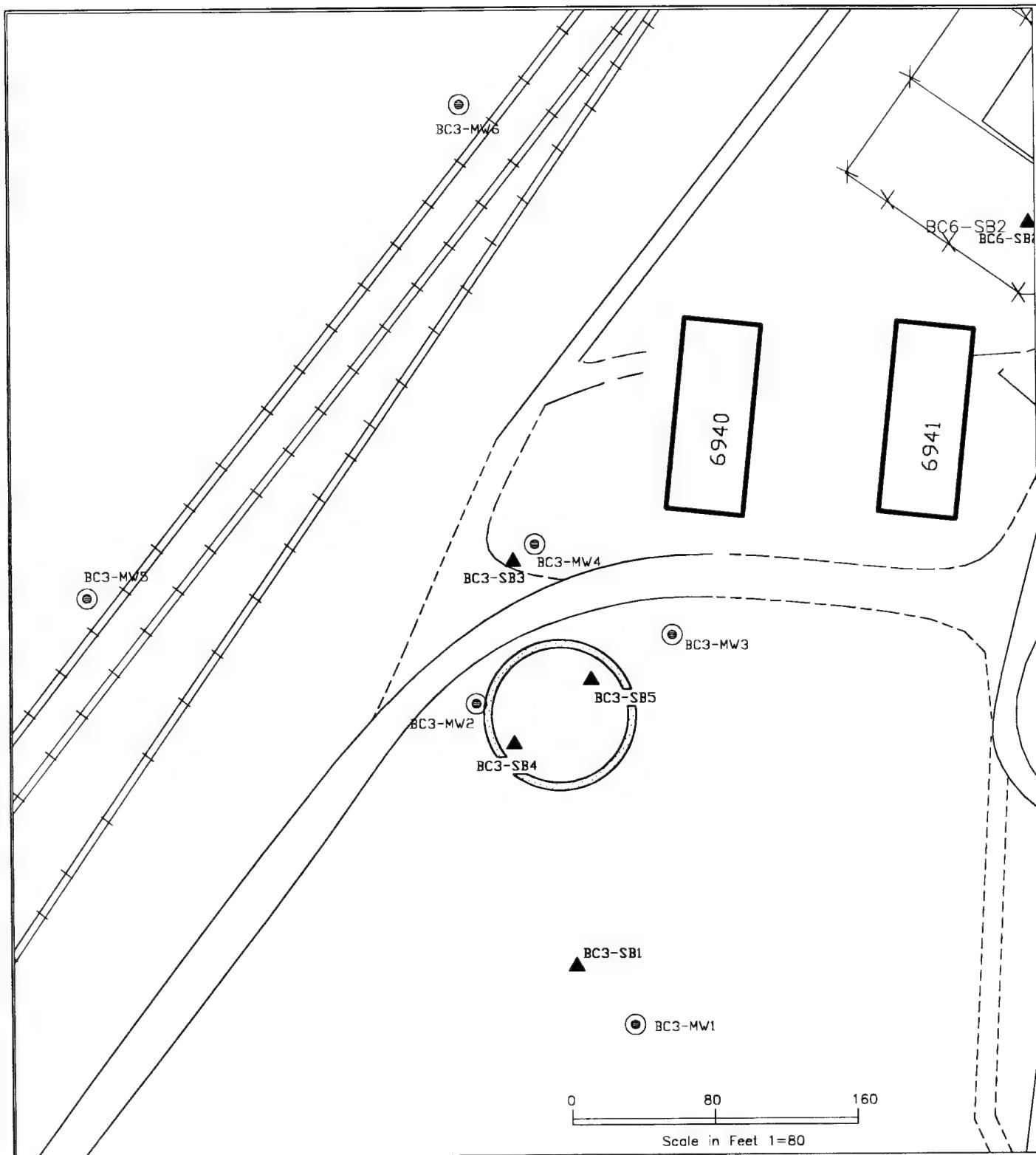
B Value is unreliable due to blank contamination value

J Reported value is estimated

Compound analyzed for but not detected

R Result is unreliable

1

**LEGEND**

- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- S Storm Drains
- G Gas
- W Water
- E Electrical



Fence
Railroad
Stream



Above Ground
Storage Tank
(Pre-existing)



Building with ID Number



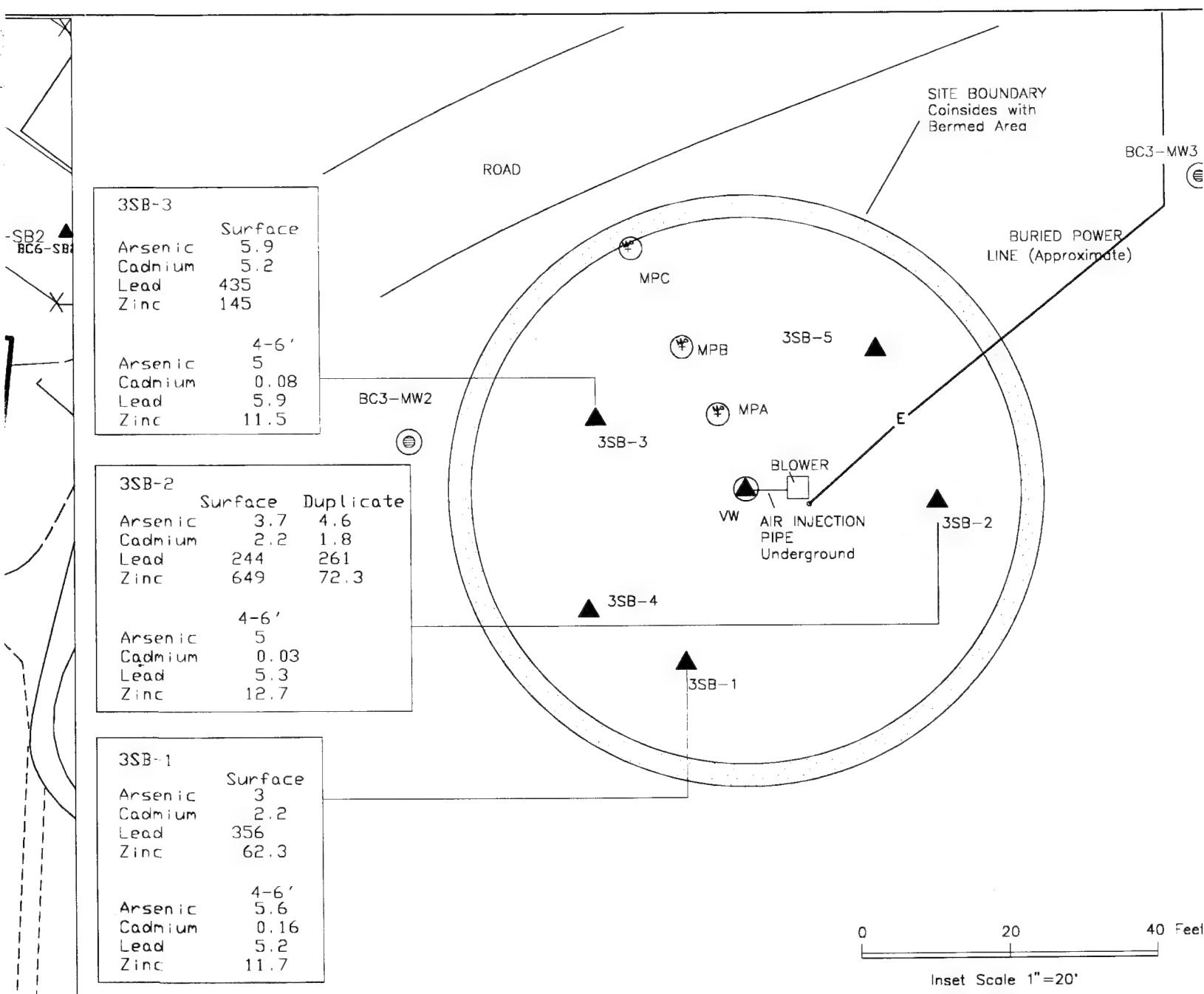
Roads



Soil Boring Location
Existing Monitoring

Units are mg/kg

(2)



INSET LEGEND

- MPA Monitoring Points (1992)
- VW Central Vent Well (1992)
- BC3-SB4 Soil Boring Location (1994)
- BC3-MW1 Monitoring Well (1992)

Soil Boring Location
Existing Monitoring Well

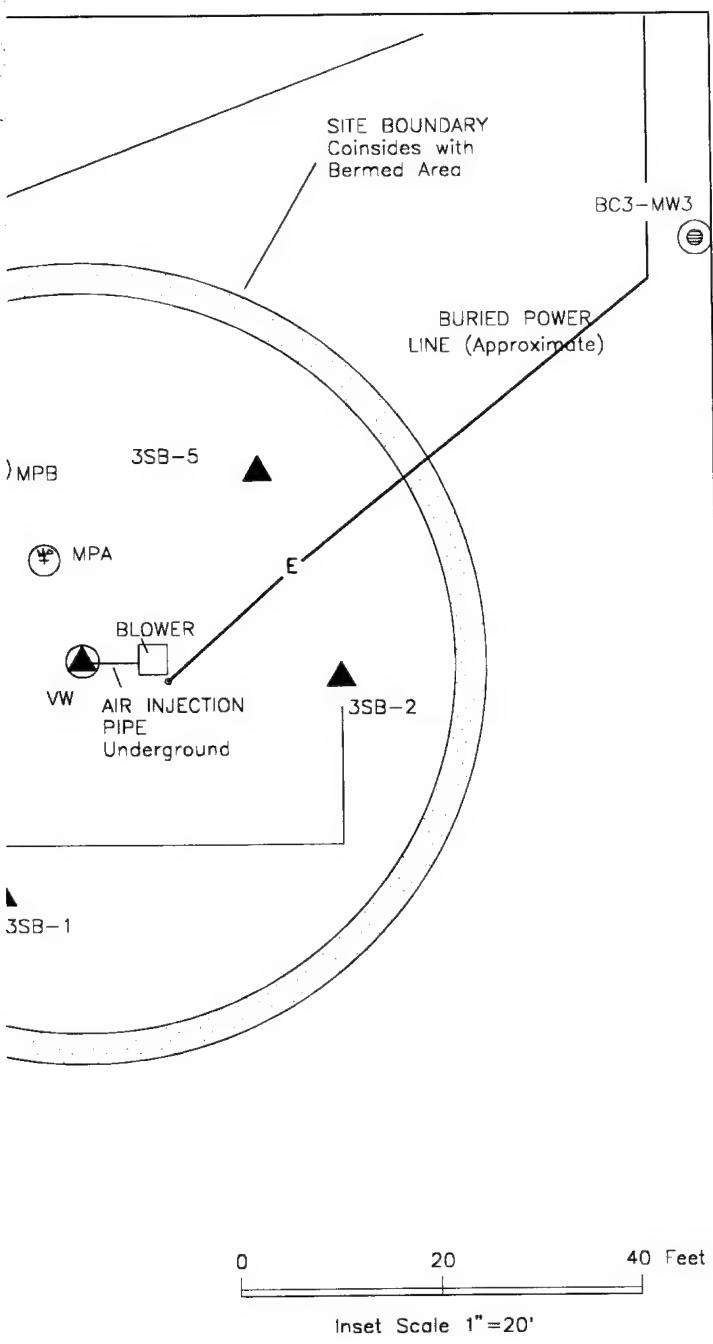
its are mg/kg

EARTH TECH

INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 3 SOIL SAMPLING RESULTS FOR ARSENIC, CADMIUM, LEAD, AND ZINC

(3)



nts (1992)
Nell (1992)
ocation (1994)
II (1992)



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 3
SOIL SAMPLING RESULTS
FOR ARSENIC, CADMIUM, LEAD,
AND ZINC**

metals with individual concentrations above background. The surface soil sample from location 3SB3 contained all six metals listed previously in concentrations above background; samples collected from locations 3SB1 and 3SB2 contain one and five metals above background, respectively.

5.4.2.2 Subsurface Soil

Subsurface soil analytical results are presented in Table 5-12. The metals antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, silver, and zinc were also detected in one or more of the subsurface soils. Only beryllium (3 detections - above background - 0.08 to 0.13 mg/kg) was detected above its respective background concentration of 0.08 mg/kg.

5.4.3 Site 3 Groundwater Analytical Results

The May 1994 Site 3 groundwater analytical results are presented in Table 5-13 and on Figure 5-11. A discussion of the results is presented in the following subsections.

VOCs

PCE, TCE, dichlorobenzene (DCB) isomers, chlorobenzene, and BTEX were detected in the groundwater samples collected and analyzed from the Site 3 monitoring wells. The groundwater sample obtained from well BC3-MW2 contained all VOCs detected in the groundwater samples with one exception. Ethylbenzene was detected in the sample collected from 3MW4 at a concentration of 0.89 µg/l. Benzene (17 µg/l) was detected in the groundwater samples collected from 3MW2 at concentrations above their respective NREPA PA 451 residential health-based drinking water criteria.

SVOC

2-Methylnaphthalene, naphthalene, 2,4-dimethylphenol, 4-methylphenol, and di-n-butyl phthalate and bis (2-ethylhexyl) phthalate were detected in the Site 3 groundwater samples. The phenol- and naphthalene-containing compounds were detected only in groundwater

Table 5-13 Site 3 Groundwater Data Summary Table
110th FW, MIANG, Battle Creek, Michigan

I. OELIFER; M. WANG;

LOCATOR:	BC3-MW1	BC3-MW2	BC3-MW3	BC3-MW4	BC3-MW5
SAMPLE ID:	BC3-MW1-GW4	BC3-MW2-GW4	BC3-MW3-GW4	BC3-MW4-GW4	BC3-MW5-GW4
COLLECTION DATE:	05/23/94	05/23/94	05/23/94	05/23/94	05/23/94
ASSOCIATED QC:	BC-TB4, BC-ER2 BC-FB1, BC-FB2				
CRITERIA UNITS:	RESULT	QUAL	RESULT	QUAL	RESULT
Halogenated Volatiles Compounds by 8010 (a)					
Tetrachloroethene	5	0.30	U	0.30	U
Trichloroethene	5	0.30	U	0.30	U
Aromatic Volatiles Compounds by 8020 (a)					
1,2-Dichlorobenzene	600	0.15	U	0.04	B
1,3-Dichlorobenzene	600	0.20	U	0.20	U
1,4-Dichlorobenzene	75	0.03	B	0.06	U
Benzene	5	0.35	UJ	0.35	U
Chlorobenzene	100	0.25	U	0.25	U
Ethylbenzene	700	0.20	UJ	0.20	U
m-Xylene	10000(b)	0.5	UJ	0.09	B
o-Xylene	10000(b)	0.20	UJ	0.20	U
p-Xylene	10000(b)	1.5	UJ	0.04	B
Semivolatiles Compounds by 8270 (a)					
2,4-Dimethylphenol	370	10	U	10	R
2-Methylnaphthalene	1D	10	U	10	U
4-Methylphenol	37	10	U	10	U
Di-n-butyl phthalate	880	2	B	3	J
Naphthalene	260	10	U	24	U
bis(2-Ethylhexyl)phthalate	6	14	B	4	J
Metals by CLP (a)(c)					
Antimony	18.2	55.30	U	33.30	U
Arsenic	50	3.50	O	39.20	U
Barium	2000	24.60	O	121	O
Chromium	700	6	U	6.60	U
Zinc	2400	4.70	O	12.80	O

Criteria for organic compounds are the NRPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NRPA PA 451 residential health-based drinking water values.

D Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

Results are presented in units of micrograms/
Total Y-chromas

Samples collected during the Site Investigation

by SW846

Data Validation Qualifiers	
I	Result is between the detection limit and the quantitation limit
B	Value is unreliable due to blank contamination value
J	Reported value is estimated
U	Compound analyzed for but not detected
R	Result is unreliable

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Table 5-13 Site 3 Groundwater Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR: BC3-MW6
SAMPLE ID: BC3-MW6-SW4
COLLECTION DATE: 05/23/94
ASSOCIATED QC: BC-TB4, BC-ER2
BC-FB1, BC-FB2

CRITERIA UNITS:	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (a)		
Tetrachloroethene	5	0.30 U
Trichloroethene	5	0.30 U
Aromatic Volatiles Compounds by 8020 (a)		
1,2-Dichlorobenzene	600	0.15 U
1,3-Dichlorobenzene	600	0.04 B
1,4-Dichlorobenzene	75	0.07 B
Benzene	5	0.11 B
Chlorobenzene	100	0.25 U
Ethylbenzene	700	0.16 U
m-Xylene	10000(b)	0.14 U
o-Xylene	10000(b)	0.11 B
p-Xylene	10000(b)	0.06 U
Semivolatiles Compounds by 8270 (a)		
2,4-Dimethylphenol	370	10 U
2-Methylnaphthalene	ID	10 U
4-Methylphenol	37	10 U
Di-n-butyl phthalate	880	2 B
Naphthalene	260	10 U
bis(2-Ethyhexyl)phthalate	6	3 B
Metals by CLP (a)(c)		
Antimony	18.2	55.30 U
Arsenic	50	2.60 U
Barium	2000	35.60 ()
Chromium	700	6 U
Zinc	2400	12.10 (B)

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA 451 residential health-based drinking water values.

ID Insufficient data available to develop criteria

NS Not Sampled

Results Qualifiers

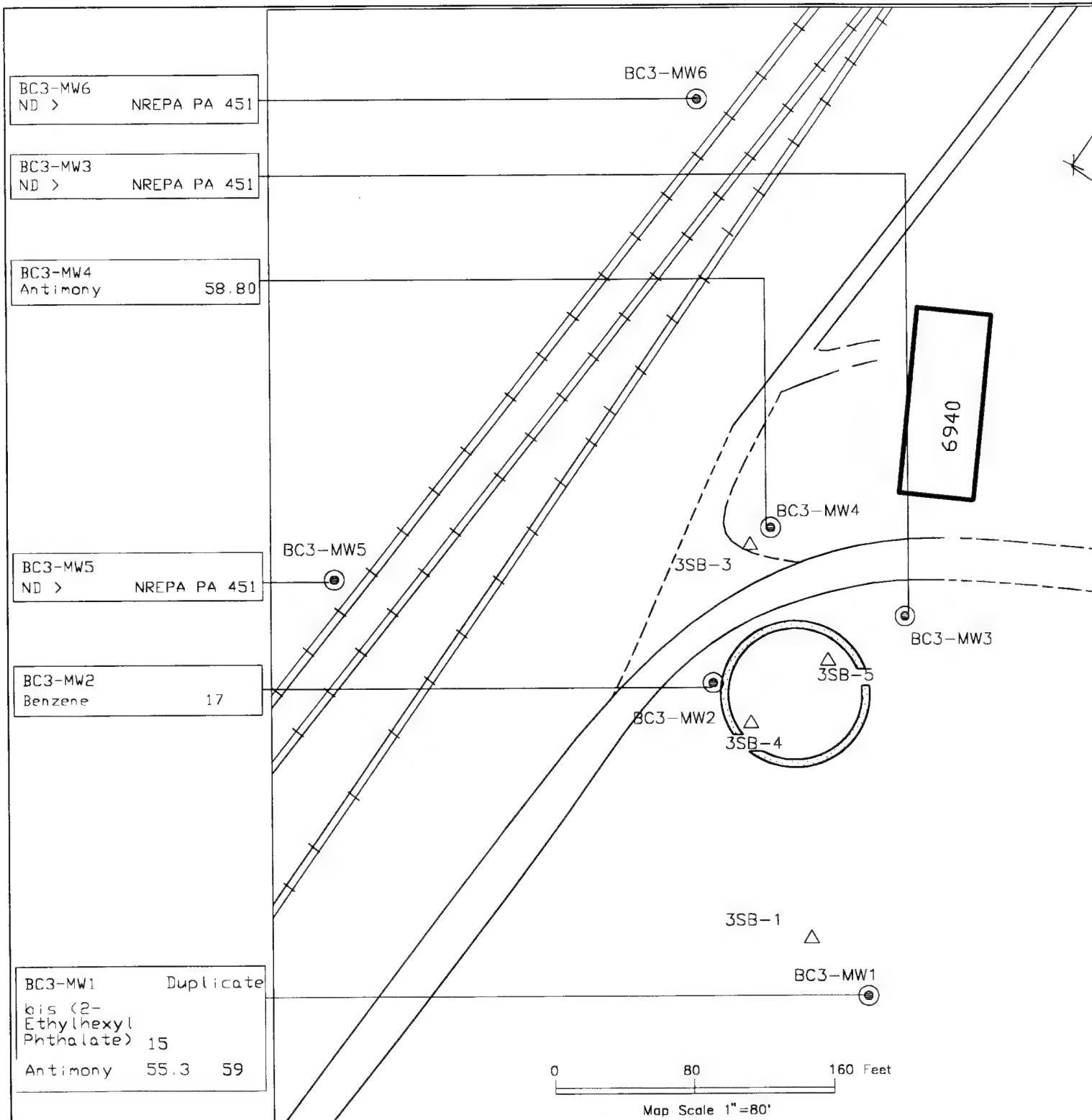
(a) Results are presented in units of micrograms/liter

(b) Total Xylenes

(c) Samples collected during the Site investigation were analyzed for metals by SW846

Data Validation Qualifiers
() Result is between the detection limit and the quantitation limit
B Value is unreliable due to blank contamination value
J Reported value is estimated
U Compound analyzed for but not detected
R Result is unreliable

(1)

**LEGEND**

- T Telephone
- OHU Overhead Utilities
- F Fire Alarm
- C Communication
- SL Sanitary Sewer Line
- S Storm Drains
- G Gas
- W Water
- E Electrical



Fence
Railroad
Stream



Above Ground
Storage Tank
(Pre-existing)



Building with ID Number



Roads

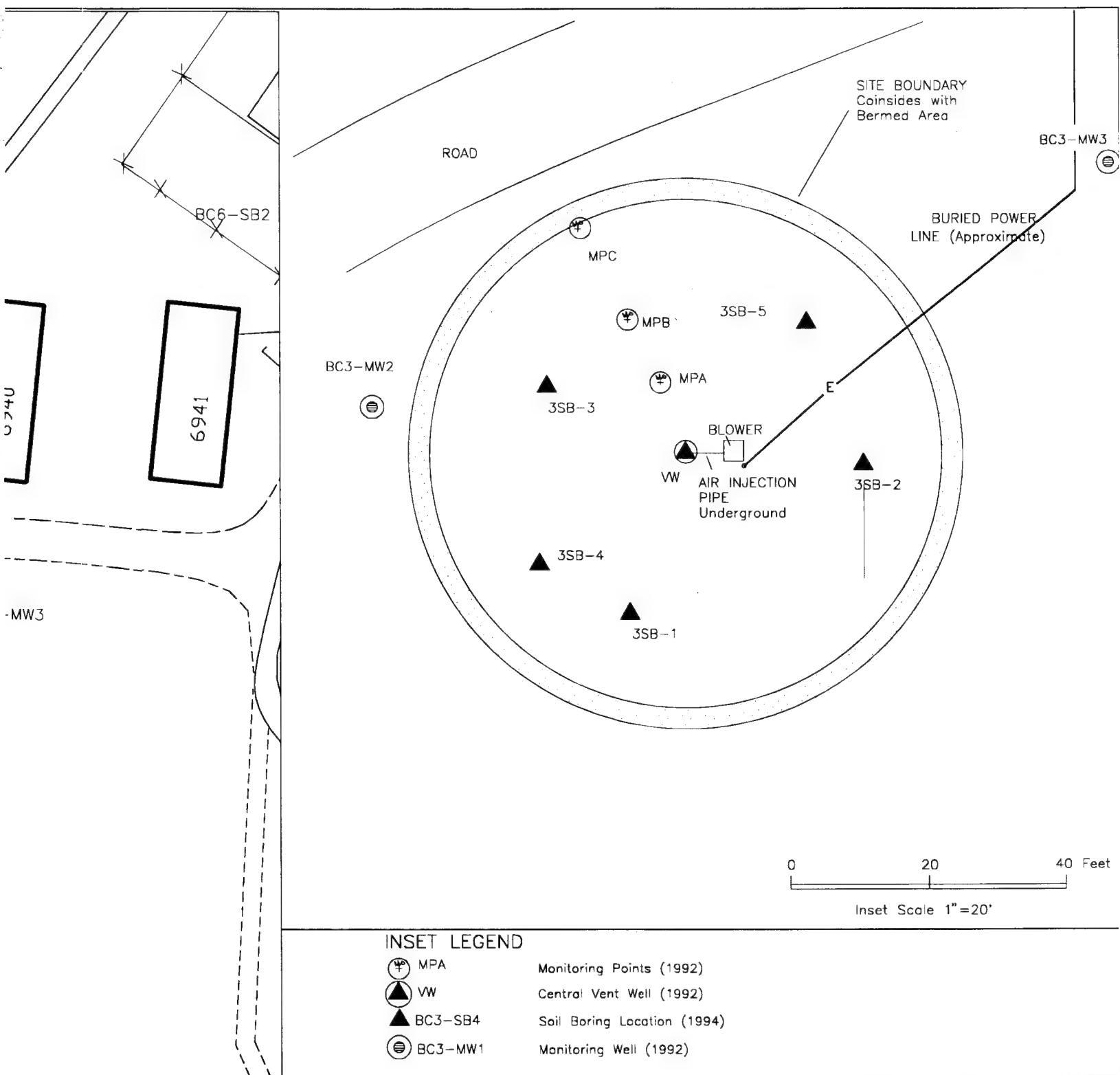


Former Soil
Existing Mon

ND > NREPA PA 451 =

Units are m
Units are m

(2)



△ Former Soil Boring Location
● Existing Monitoring Well

NREPA PA 451 = No detection greater
than the NREPA PA 451 residential health-
based drinking water value

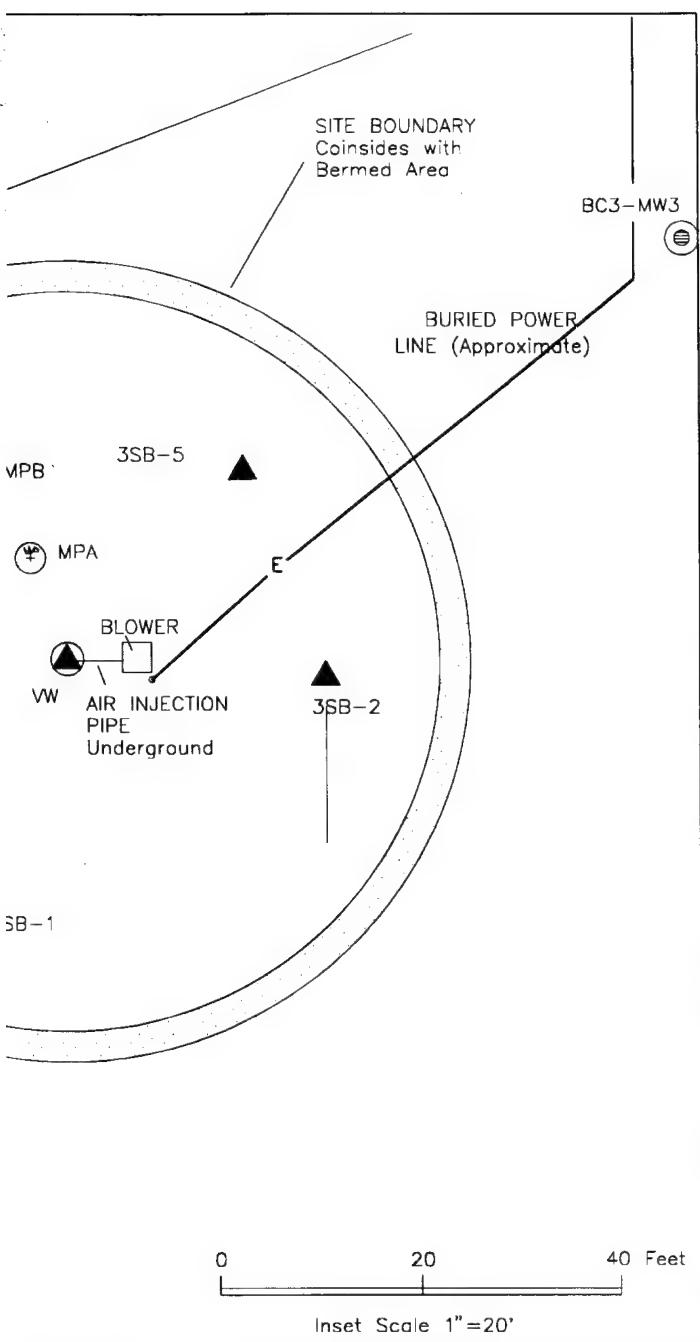
Units are ug/l for organics
Units are mg/l for metals

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INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

SITE 3 GROUNDWATER SAMPLING RESULTS MAY 1994

(3)



s (1992)
II (1992)
ation (1994)
(1992)



INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

**SITE 3
GROUNDWATER SAMPLING RESULTS
MAY 1994**

collected from well 3MW2; concentrations were below all respective NREPA PA 451 residential health-based drinking water criteria. Phthalate esters were detected in groundwater samples from two wells; 3MW1 and 3MW3. Bis (2-ethylhexyl) phthalate was detected in the groundwater sample collected from 3MW1 at a concentration above all respective NREPA PA 451 residential health-based drinking water criteria.

Metals

Antimony, arsenic, barium, chromium, and zinc were detected in one or more of the groundwater samples collected and analyzed from Site 3. Antimony was detected in samples collected from BC3-MW1 and BC3-MW4 above background concentrations, while arsenic ($39.2 \mu\text{g/l}$) was detected in samples collected from well BC3-MW2 at concentrations above background; this concentration is below the NREPA PA 451 residential health-based drinking water value of $50 \mu\text{g/l}$.

5.5 BASE BOUNDARY GROUNDWATER INVESTIGATIONS

The following investigation activities were performed to support the base boundary investigation:

- Groundwater samples were collected in May 1994 from wells BC-MW1 through BC-MW15 and shipped to an analytical laboratory for analyses of VOCs, SVOCs, TAL metals (filtered only), chloride, sulfate, total dissolved solids (TDS), and nitrate.
- Two rounds of groundwater elevation measurements were collected from the existing base boundary wells during May 1994 and December 1994. The May 1994 measurements included the MDNR wells north of the abandoned landfills (CDM, 1992).
- One groundwater monitoring well, BC-MW16, was installed (December 1994) between the northern base boundary and the remainder of the base.

- Wells BC-MW16 and BC-MW4 were sampled during December 1994 and analyzed for VOCs, SVOCs, PP metals plus barium, chloride and sulfate.

Base Hydrogeology

Descriptions of the base geology and hydrogeology were presented in Sections 3.4 and 3.5, respectively. A brief discussion of the hydrogeology is presented in the following subsections.

Hydrogeology

The groundwater contained in the glacial aquifer beneath the base flows north and northwest, exiting the base along Dickman Road. After exiting the base, groundwater flows beneath two abandoned landfills (Figures 5-2 and 5-3).

The hydraulic conductivity for the surficial aquifer beneath the main portion of the base averages 8.8×10^{-3} cm/sec (25 ft/day). These data were obtained from the slug-testing results for wells BC-MW1 and BC-MW3, which were reported by Engineering Science (1993). The hydraulic gradient between the hangars and the base boundary is approximately 0.004. The v beneath Site 1 is 106 ft/yr (0.29 ft/day), which was calculated using the following equation (Freeze and Cherry, 1979):

$$v = \frac{k}{n} \times \frac{dh}{dl}$$

where:

k = hydraulic conductivity

n = porosity (assumed to be 35% for unconsolidated glacial drift)

$\frac{dh}{dl}$ = hydraulic gradient

5.5.1 Previous Results

Figure 5-12 presents the historic groundwater analytical data collected from 1989 and 1991 and reported in the Final SI Report (ES, 1993). As shown on Figure 5-12, relatively low

concentrations (0.23 to 92 $\mu\text{g/l}$) of the VOCs, benzene, TCE, 1,1,1-TCA, chloroform, acetone, 1,1,2,2-PCA, toluene, 1,2,-dichloroethylene (DCE), and 2-butanone were detected in the groundwater samples. The origin of VOCs in these wells was unknown.

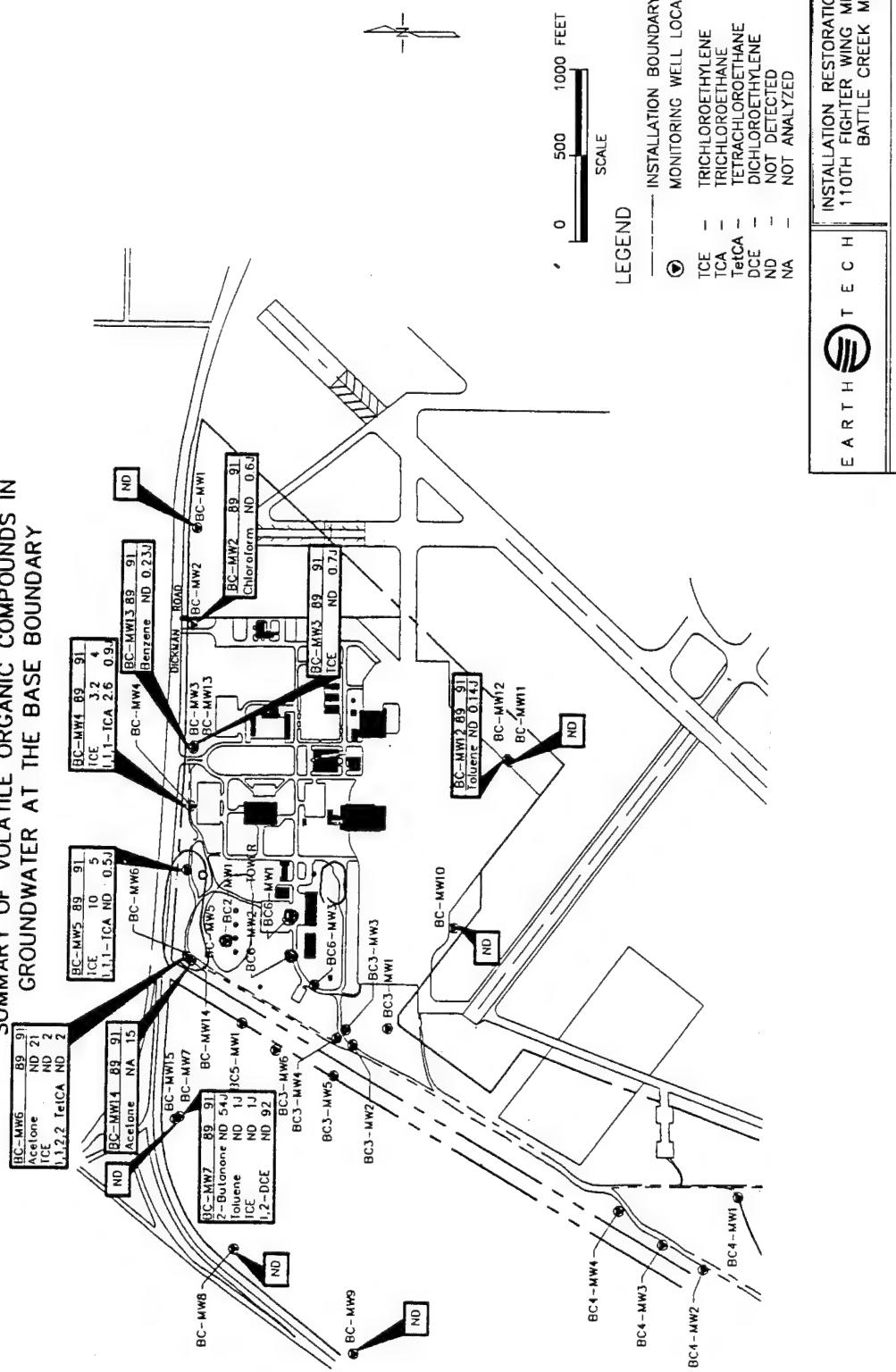
After the installation of these wells, the MDNR completed an environmental assessment of the abandoned landfills north of Dickman Road (CDM, June 1992). This assessment included the installation of three well clusters on the north side (down-gradient) of the abandoned landfills. As a part of this assessment groundwater samples were collected in January 1992 from the base boundary wells (BC-MW1 through BC-MW6 and BC-MW11(water table wells) and BC-MW13 and BC-MW14.

Figure 5-13 presents the arsenic, sodium, and TCE data from the January 1992 sampling event (water table wells). Isoconcentration lines are included on this map for the sodium data. As illustrated on this figure, the highest sodium and arsenic concentrations occur in wells MW103 (99,000 mg/l) and MW105 (429,000 mg/l), which are located down-gradient of the abandoned landfills. Relatively high sodium concentrations were present in MW107, which also contained TCE at a concentration of 400 $\mu\text{g/l}$. The concentrations of sodium in the base boundary wells increased from the east (BC-MW1) to the west (BC-MW5) and then decreased again to the west of BC-MW6. Well BC-MW5 also contained arsenic at a concentration of 3 $\mu\text{g/l}$. These data suggest that a source of groundwater contamination containing TCE, sodium, and arsenic is located north of the base boundary. These components are diffusing or dispersing up- and/or cross-gradient and are suspected of having adversely affected water quality along the base boundary.

5.5.2 Groundwater Analytical Results

The groundwater analytical results for the base boundary wells are presented in the following subsections. Groundwater analytical results for the May 1994 and December 1994 sampling are included in Tables 5-14 and 5-15. The analytical results are presented on Figure 5-14.

MICHIGAN NATIONAL GUARD BASE
BATTLE CREEK, MICHIGAN
SUMMARY OF VOLATILE ORGANIC COMPOUNDS IN
GROUNDWATER AT THE BASE BOUNDARY

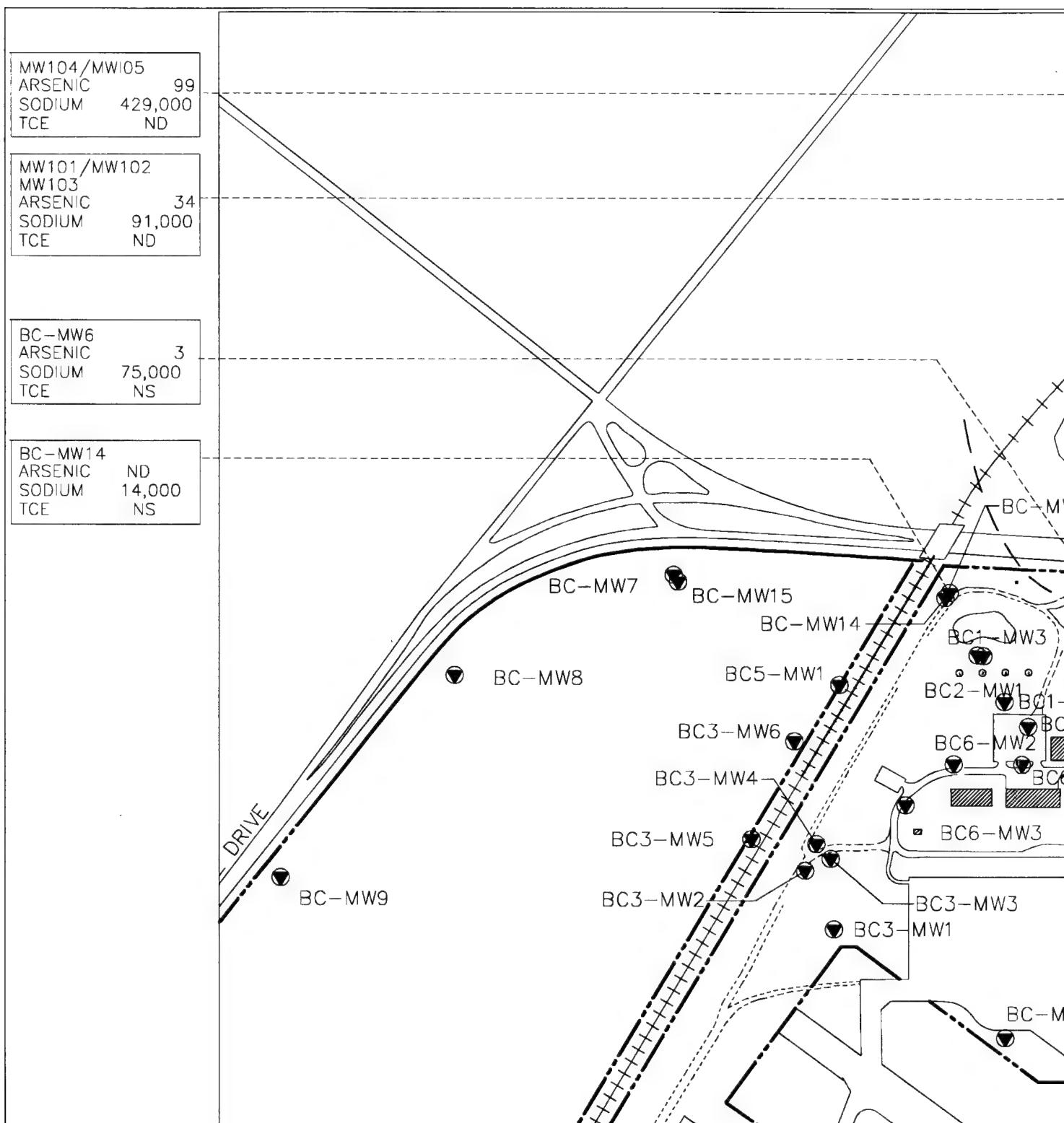


SOURCE: ENGINEERING-SCIENCE NOV. 1993

HISTSMRY.DWG 6/95 12/95 12/95

FIGURE 5-12

(1)



LEGEND

— Installation Boundary



Roads



Above Ground
Storage Tank
(Pre-existing)



Building



Existing Monitoring Well



Iso-concentrations (ug/l) Sodium

50,000

50,000

50,000

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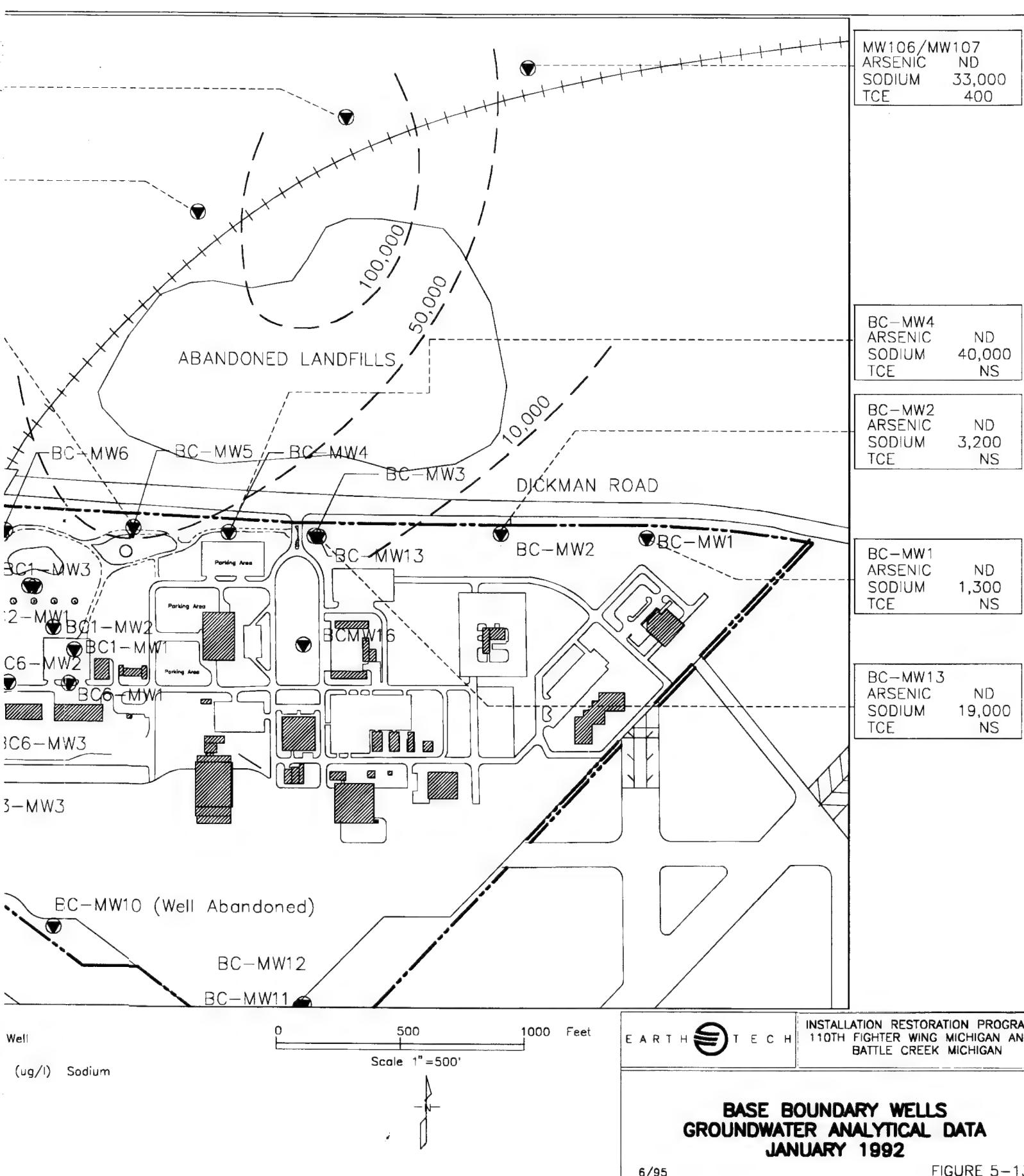


FIGURE 5-13

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW1	BC-MW2	BC-MW3	BC-MW4	BC-MW5	BC-MW6
SAMPLE ID:	BC-MW1-GW4	BC-MW2-GW4	BC-MW3-GW4	BC-MW4-GW4	BC-MW5-GW4	BC-MW6-GW4
COLLECTION DATE:	05/19/94	05/19/94	05/20/94	05/23/94	05/23/94	05/22/94
ASSOCIATED QC:	BC-TB1, BC-ER1	BC-TB1, BC-ER1	BC-ER1	BC-TB5, BC-ER3	BC-TB5, BC-ER1	BC-TB5, BC-ER1
	BC-FB1, BC-FB2, BC-FB3 BC-FB1, BC-FB2, BC-FB3 BC-FB1, BC-FB2, BC-FB3 BC-FB1, BC-FB2, BC-FB3					
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (a)						
1,1,1-Trichloroethane	200	0.35	U	0.03	0.07	0.52
1,1,2,2-Tetrachloroethane	4.3	0.40	U	0.40	0.40	0.40
1,1-Dichloroethane	880	0.35	U	0.35	0.35	0.19
1,2-Dichloroethane	5	0.25	U	0.25	0.25	0.28
Chloroform	100	0.35	U	0.07	B	0.35
Trans-1,2-Dichloroethene	100	0.30	U	0.30	U	0.30
Trichloroethene	5	0.30	U	0.30	U	0.50
Aromatic Volatiles Compounds by 8020 (a)						
1,2-Dichlorobenzene	600	0.15	U	0.15	U	0.15
Benzene	5	0.35	U	0.35	U	0.06
Chlorobenzene	100	0.25	U	0.25	U	0.25
Ethylbenzene	700	0.02	U	0.20	U	0.20
Methyl-tert-butyl ether	240	0.10	U	5	U	5
Semi挥发性 Compounds by CLP (a)						
Benzoic acid	32000	100	UJ	100	U	100
Di-n-butyl phthalate	800	2	B	2	B	2
bis(2-Ethylhexyl)phthalate	6	10	U	1	B	B
Metals by CLP (a)(b)						
Aluminum	62.2	62.20	U	62.20	U	122
Arsenic	50	2.60	UJ	2.60	U	9.30
Barium	2000	24.10	0	28.80	0	93.70
Calcium	73850	97400	0B	78600	0	107000
Iron	356	32.80	0B	24.40	U	364
Lead	4	1.80	U	1.80	UJ	1.80
Magnesium	14973	19900	U	18600	U	25300
Manganese	807	1.20	U	1.20	U	2.40
Nickel	100	16.60	U	16.60	U	16.60
Potassium	1839	714	U	931	0	5350
Sodium	160000	3420	0	3590	0	66500
Zinc	2400	4.70	0B	6.50	12	0B

Criteria for organic compounds are the NREPA PA-451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA-451 residential health-based drinking water values.

- ID Insufficient data available to develop criteria
- NS Not sampled
- (a) Results are presented in units of micrograms/litter
- (b) Samples collected during the Site investigation were analyzed for metals by SW846
- (c) Results are presented in units of milligrams/litter
- (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/litter, respectively
- (e) Criteria does not exist

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW1	BC-MW2	BC-MW3	BC-MW4	BC-MW5	BC-MW6
SAMPLE ID:	BC-MW1-GW4	BC-MW2-GW4	BC-MW3-GW4	BC-MW4-GW4	BC-MW5-GW4	BC-MW6-GW4
COLLECTION DATE:	05/19/94	05/19/94	05/20/94	05/23/94	05/23/94	05/22/94
ASSOCIATED QC:	BC-TB1, BC-ER1	BC-TB1, BC-ER1	BC-ER1	BC-TB5, BC-ER3	BC-TB5, BC-ER1	BC-TB5, BC-ER1
	BC-FB1, BC-FB2, BC-FB3	BC-FB3				
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Water Quality Parameters(c)						
Chloride	ID(d)	10	7.23	71.40	152	159
Sulfate	ID(d)	32.50	16.70	22.40	33.90	28.80
Dissolved Solids	(e)	354	301	437	636	608
Nitrate	10	3.4	2.1	3.6	4.0	1.9

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA451 residential health-based drinking water values.

- Data Validation Qualifiers**
- ID Insufficient data available to develop criteria
 - NS Not Sampled
 - U Compound analyzed for but not detected
 - R Result is unreliable
 - B Value is unreliable due to blank contamination value
 - J Reported value is estimated
 - I Result is between the detection limit and the quantitation limit

Result Qualifiers

- (a) Results are presented in units of micrograms/liter
- (b) Samples collected during the Site Investigation were analyzed for metals by SW846
- (c) Results are presented in units of milligrams/liter
- (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/liter, respectively
- (e) Criteria does not exist

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW7	BC-MW8	BC-MW9	BC-MW9	BC-MW11	BC-MW12
SAMPLE ID:	BC-MW7-GW4	BC-MW8-GW4	BC-MW9-GW4	BC-MW9-GW4D	BC-MW11-GW4	BC-MW12-GW4
COLLECTION DATE:	05/24/94	05/24/94	05/23/94	05/23/94	05/23/94	05/23/94
ASSOCIATED QC:	BC-TB6, BC-ER3	BC-TB6, BC-ER3	BC-TB5, BC-ER3	BC-TB5, BC-ER3	BC-TB4, BC-ER1	BC-TB4, BC-ER1
	BC-FB1, BC-FB2, BC-FB3					
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (a)						
1,1,1-Trichloroethane	200	0.35	U	0.35	U	0.35
1,1,2,2-Tetrachloroethane	4.3	0.40	U	0.40	U	0.40
1,1-Dichloroethane	880	0.35	U	0.35	U	0.35
1,2-Dichloroethane	5	0.25	U	0.25	U	0.25
Chloroform	100	0.35	U	0.35	U	0.35
Trans-1,2-Dichloroethene	100	0.15	U	0.30	U	0.30
Trichloroethene	5	3.60	U	0.30	U	0.30
Aromatic Volatiles Compounds by 8020 (a)						
1,2-Dichlorobenzene	600	0.15	U	0.03	B	0.05
Benzene	5	0.03	B	0.35	U	0.35
Chlorobenzene	100	0.25	U	0.25	U	0.25
Ethylbenzene	700	0.20	U	0.08	B	0.20
Methyl-tert-butyl ether	240	5	U	5	U	5
Semivolatile Compounds by CLP (a)						
Benzoic acid	32000	100	U	100	U	4
Di-n-butyl phthalate	800	10	U	10	U	2
bis(2-Ethylhexyl)phthalate	6	1	U	2	U	1
Metals by CLP (a)(b)						
Aluminum	62.2	137	0	156	0	188
Arsenic	50	2.60	U	2.60	U	2.60
Barium	2000	27.60	0B	24.90	0B	26.30
Calcium	73850	72900	U	78000	U	68200
Iron	356	94.50	0U	191	634	546
Lead	4	1.80	UJ	1.80	UJ	2
Magnesium	14973	16900	U	19500	U	16600
Manganese	807	6.30	U	6.30	U	167
Nickel	100	38.80	U	38.80	U	38.80
Potassium	1839	2309.30	U	2309.30	U	2309.30
Sodium	160000	2750	0	4650	0	3100
Zinc	2400	8	U	20.60	U	10.30

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA451 residential health-based drinking water values.

- ID Insufficient data available to develop criteria
- NS Not Sampled
- Result Qualifiers
 - (a) Results are presented in units of micrograms/litter
 - (b) Samples collected during the Site Investigation were analyzed for metals by SW846
 - (c) Results are presented in units of milligrams/litter
 - (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/litter, respectively
 - (e) Criteria does not exist

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW7	BC-MW8	BC-MW9	BC-MW11
SAMPLE ID:	BC-MW7-GW4	BC-MW8-GW4	BC-MW9-GW4	BC-MW11-GW4
COLLECTION DATE:	05/24/94	05/24/94	05/23/94	05/23/94
ASSOCIATED QC:	BC-TB6, BC-ER3	BC-TB6, BC-ER3	BC-TB5, BC-ER3	BC-TB4, BC-ER1
	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3
CRITERIA:	RESULT	QUAL	RESULT	QUAL
Water Quality Parameters(c)				
Chloride	ID(d) ID(a)	5.86 22.50	9.16 29.80	3.0 10.8
Sulfate	(e)	295	326	259
Dissolved Solids		10	1.2	0.4
Nitrate		<0.2		<0.2

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA451 residential health-based drinking water values.

Data Validation Qualifiers

- (i) Result is between the detection limit and the quantitation limit
- (j) Value is unreliable due to blank contamination value
- (k) Reported value is estimated
- (l) Compound analyzed for but not detected
- (m) Result is unreliable

ID Insufficient data available to develop criteria

NS Not Sampled

Result Qualifiers

- (a) Results are presented in units of micrograms/liter
- (b) Samples collected during the Site investigation were analyzed for metals by SW846
- (c) Results are presented in units of milligrams/liter
- (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/liter, respectively
- (e) Criteria does not exist

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table (Continued)
110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW13 BC-MW13-GW4 05/20/94 BC-ER1	BC-MW13 BC-MW13-GW4D 05/20/94 BC-ER1	BC-MW14 BC-MW14-GW4 05/22/94 BC-TB5, BC-ER1	BC-MW15 BC-MW15-GW4 05/24/94 BC-TB6, BC-ER3				
CRITERIA:	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (a)								
1,1,1-Trichloroethane	200	0.35	U	0.35	U	0.40	U	0.35
1,1,2,2-Tetrachloroethane	4.3	0.40	UJ	0.40	U	0.40	UJ	0.40
1,1-Dichloroethane	880	0.35	U	0.35	U	0.35	U	0.35
1,2-Dichloroethane	5	0.25	U	0.25	U	0.25	U	0.25
Chloroform	100	0.06	U	0.35	U	0.35	U	0.05
Trans-1,2-Dichloroethene	100	0.30	U	0.30	U	0.30	U	0.04
Trichloroethene	5	0.30	U	0.30	U	0.30	U	0.30
Aromatic Volatiles Compounds by 8020 (a)								
1,2-Dichlorobenzene	600	0.03	U	0.15	U	0.06	B	0.15
Benzene	5	0.35	U	0.35	U	0.08	B	0.04
Chlorobenzene	100	0.25	U	0.25	U	0.06	B	0.25
Ethylbenzene	700	0.20	U	0.20	U	0.06	B	0.20
Methyl-tert-butyl ether	240	5	U	5	U	0.08	B	5
Semivolatiles Compounds by CLP (a)								
Benzoic acid	32000	100	UJ	100	UJ	100	UJ	100
Di-n-butyl phthalate	800	2	B	2	B	2	B	10
bis(2-Ethylhexyl)phthalate	6	41	B	16	B	6	B	37
Metals by CLP (a)(b)								
Aluminum	62.2	62.20	U	62.20	U	62.20	U	166
Arsenic	50	5	0B	2.60	U	7.70	0B	4.10
Barium	2000	86.90	0	89.70	0	75.10	0	64.40
Calcium	73850	104000	U	105000	U	76800	U	72700
Iron	356	819	9:17	1.80	U	2100	J	1060
Lead	4	1.80	U	25400	U	1.80	U	1.80
Magnesium	14973	24800	U	205	U	20600	B	17200
Manganese	807	200	U	16.60	U	79.40	U	230
Nickel	100	16.60	U	1280	0	16.60	U	48
Potassium	1839	1440	0	11400	0	767	0	2309.30
Sodium	160000	11100	B	11.20	0B	3330	0	3070
Zinc	2400	28	B	11.20	0B	15.90	0B	68.50

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA451 residential health-based drinking water values.

ID Insufficient data available to develop criteria
NS Not Sampled

5-68 Result Qualifiers

- (a) Results are presented in units of micrograms/liter
- (b) Samples collected during the Site investigation were analyzed for metals by SW446
- (c) Results are presented in units of milligrams/liter
- (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/liter, respectively
- (e) Criteria does not exist

Data Validation Qualifiers
 (I) Result is between the detection limit and the quantitation limit
 (B) Value is unreliable due to blank contamination value
 (R) Compound analyzed for but not detected
 (U) Result is unreliable

Table 5-14 Basewide Groundwater, May 1994 Data Summary Table (Continued)

110th FW, MIANG, Battle Creek, Michigan

LOCATOR:	BC-MW13	BC-MW13	BC-MW14	BC-MW15
SAMPLE ID:	BC-MW13-GW4	BC-MW13-GW4D	BC-MW14-GW4	BC-MW15-GW4
COLLECTION DATE:	05/20/94	05/20/94	05/22/94	05/24/94
ASSOCIATED QC:	BC-ER1	BC-ER1	BC-TB5, BC-ER1	BC-TB6, BC-ER3
		BC-FB1, BC-FB2, BC-FB3	BC-FB1, BC-FB2, BC-FB3	
CRITERIA:	RESULT	QUAL	RESULT	QUAL
Water Quality Parameters(c)				
Chloride	ID(d)	36.30	36.70	8.87
Sulfate	ID(d)	37	42.90	32.60
Dissolved Solids	(e)	428	402	324
Nitrate	10	<0.2	<0.2	0.8

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA451 residential health-based drinking water values.

Data Validation Qualifiers

- ID Insufficient data available to develop criteria
- NS Not Sampled
- I Result is between the detection limit and the quantitation limit
- B Value is unreliable due to blank contamination value
- J Reported value is estimated
- U Compound analyzed for but not detected
- R Result is unreliable

Result Qualifiers

- (a) Results are presented in units of micrograms/liter
- (b) Samples collected during the Site investigation were analyzed for metals by SW846
- (c) Results are presented in units of milligrams/liter
- (d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/liter, respectively
- (e) Criteria does not exist

Table 5-15 Basewide Groundwater, December Data Summary Table

LOCATOR:	BC-MW4	BC-MW16
SAMPLE ID:	BC-MW4-GW5	BC-MW16-GW5
COLLECTION DATE:	12/17/94	12/18/94
ASSOCIATED QC:	BC-TB2	BC-TB2
	BC-FB1	BC-FB1
CRITERIA:	RESULT	QUAL
	RESULT	QUAL
Halogenated Volatiles Compounds by 8010 (a)		
1,1,1-Trichloroethane	200	0.47
Methylene chloride	5	0.03
Tetrachloroethene	5	0.30
Trichloroethene	5	2.10
	B	(B)
	U	U
	B	B
		3.20
Metals by CLP (a)(b)		
Aluminum	62.2	79.90
Barium	2000	46.60
Calcium	73850	104000
Copper	1400	4.70
Magnesium	14973	24000
Manganese	807	5.70
Potassium	1839	4770
Sodium	160000	26300
Zinc	2400	2.50
Water Quality Parameters (c)		
Chloride	ID(d)	60.6
Sulfate	ID(d)	50
Water Quality Parameters (c)		
Chloride	ID(d)	44.4
Sulfate	ID(d)	20.2

Criteria for organic compounds are the NREPA PA 451 residential health-based drinking water values; for inorganic compounds they are the higher of the background or the NREPA PA 451 residential health-based drinking water values.

ID Insufficient data available to develop criteria
NS Not Sampled

Result Qualifiers
(a) Results are presented in units of micrograms/liter
(b) Samples collected during the Site investigation were analyzed for metals by SW846

(c) Results are presented in units of milligrams/liter
(d) Aesthetic drinking water values for sulfate and chloride are 250 milligrams/liter, respectively

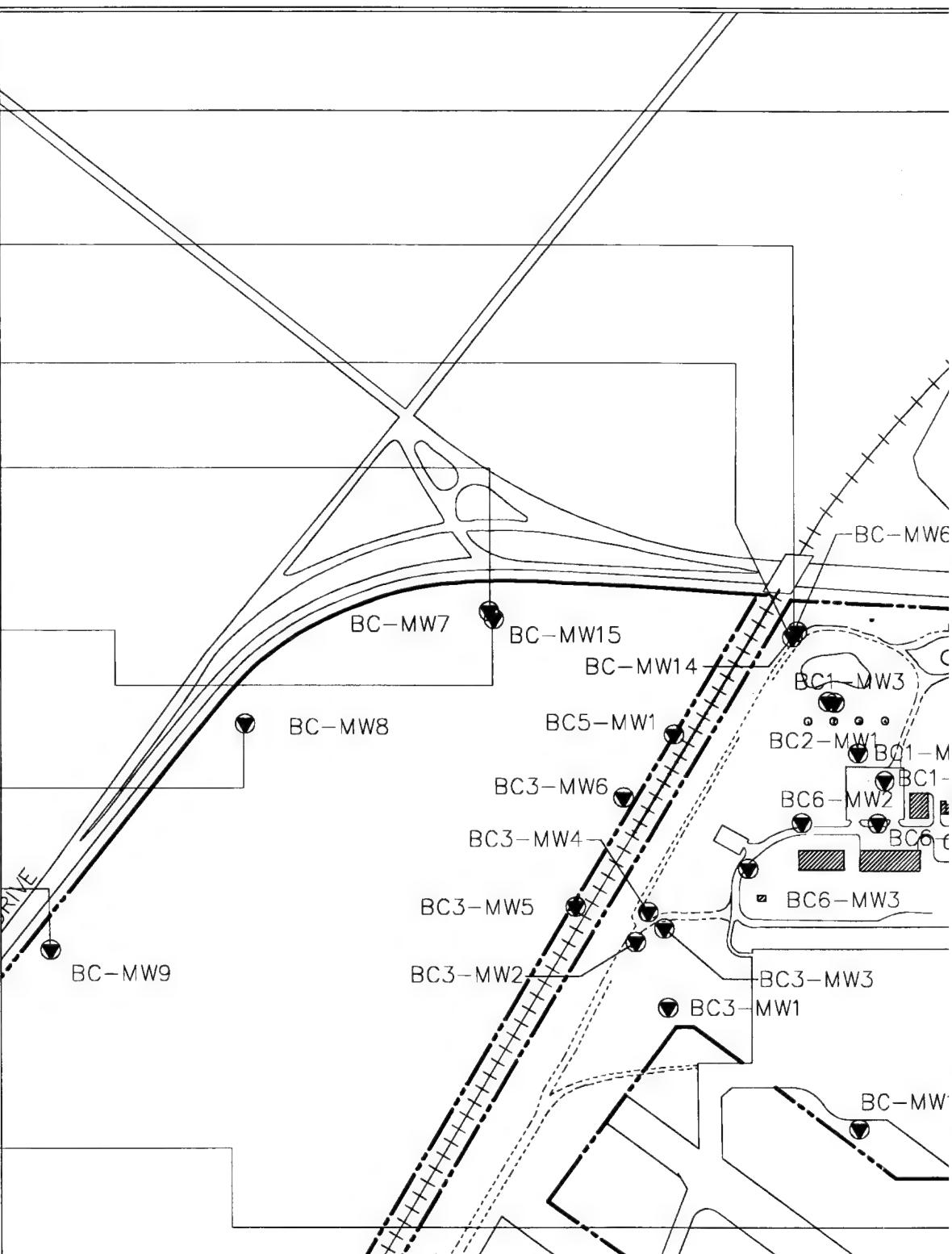
Data Validation Qualifiers
(i) Result is between the detection limit and the quantitation limit
(j) Value is unreliable due to blank contamination value
(k) Reported value is estimated
(l) Compound analyzed for but not detected
(R) Result is unreliable

1

BC-MW5	MAY 1994
Iron	364
Aluminum	122
Chloride	159
Sodium	67,100
BC-MW6	MAY 1994
Aluminum	139
Chloride	58.1
Sodium	26,000
BC-MW14	MAY 1994
Iron	2,100
Chloride	8.9
Sodium	3,330
BC-MW7	MAY 1994
Aluminum	137
Chloride	5.9
Sodium	2,750
BC-MW15	MAY 1994
Aluminum	166
Iron	1,060
Bis (2-Ethylhexyl)	
Phthalate	37
Chloride	3.8
Sodium	3,070
BC-MW8	MAY 1994
Aluminum	156
Chloride	9.2
Sodium	4,650
BC-MW9	MAY 1994
Iron	634
Aluminum	188
Chloride	3
Sodium	3,100
BC-MW9	Duplicate
Iron	546
Aluminum	62.2
Chloride	3.31
Sodium	2,620
BC-MW12	MAY 1994
Iron	808
Bis (2-Ethylhexyl)	
Phthalate	22
Chloride	13.3
Sodium	8,520

LEGEND

Well Number	Date Sampled
Analytes Above NREPA PA451	Concentration
Chloride, sodium for information only	Concentration



— Installation Boundary

Roads

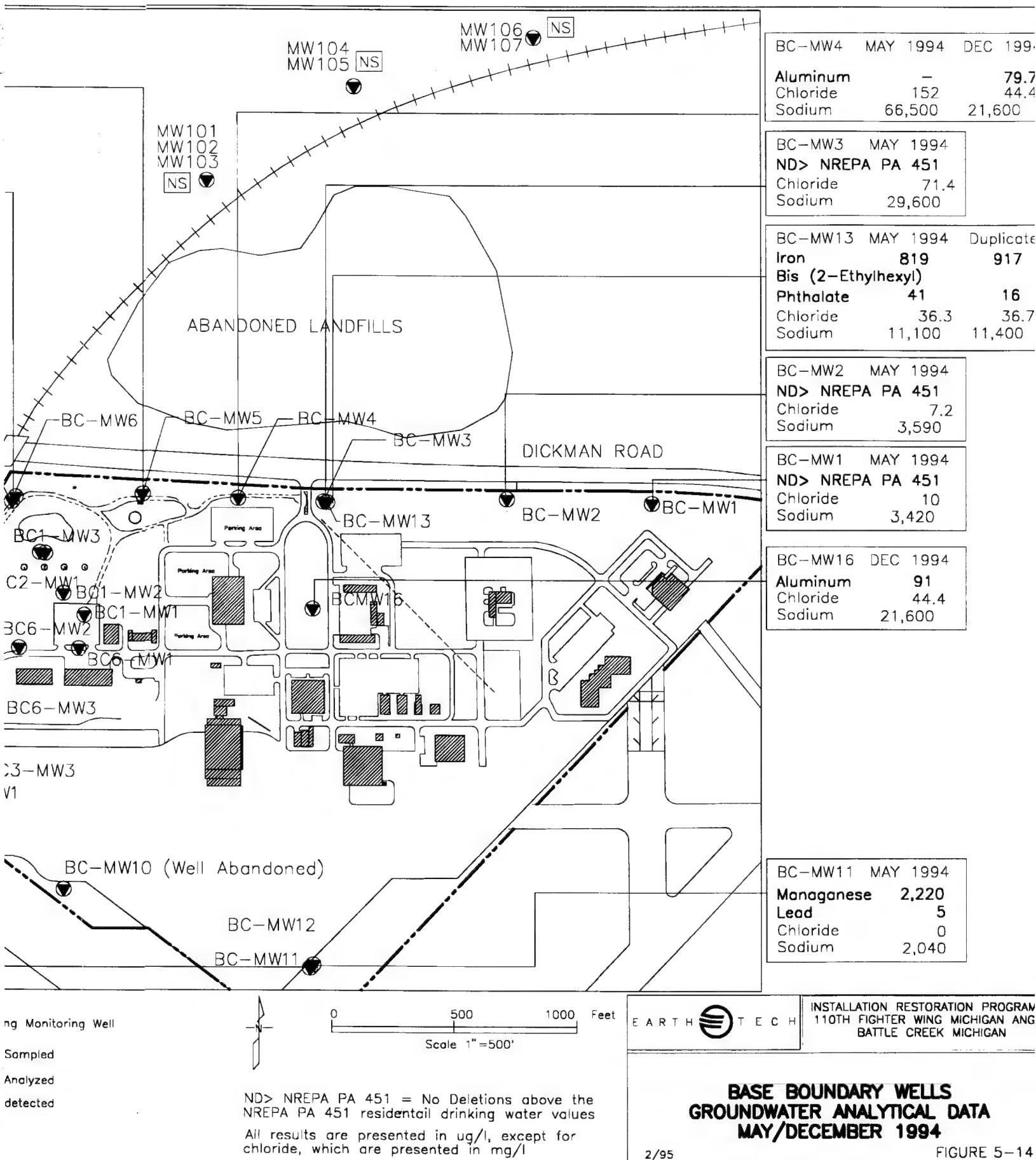
Rodas

3 Above Ground
Storage Tank
(Pre-existing)

Building

 Existing Monitoring Well
NS= Not Sampled
NA= Not Analyzed
ND= Not detected

(2)



(3)

BC-MW4 MAY 1994 DEC 1994
Aluminum - 79.7
Chloride 152 44.4
Sodium 66,500 21,600
BC-MW3 MAY 1994
ND> NREPA PA 451
Chloride 71.4
Sodium 29,600
BC-MW13 MAY 1994 Duplicate
Iron 819 917
Bis (2-Ethylhexyl)
Phthalate 41 16
Chloride 36.3 36.7
Sodium 11,100 11,400
BC-MW2 MAY 1994
ND> NREPA PA 451
Chloride 7.2
Sodium 3,590
BC-MW1 MAY 1994
ND> NREPA PA 451
Chloride 10
Sodium 3,420
BC-MW16 DEC 1994
Aluminum 91
Chloride 44.4
Sodium 21,600
BC-MW11 MAY 1994
Manganese 2,220
Lead 5
Chloride 0
Sodium 2,040

et EARTH TECH INSTALLATION RESTORATION PROGRAM
110TH FIGHTER WING MICHIGAN ANG
BATTLE CREEK MICHIGAN

BASE BOUNDARY WELLS
GROUNDWATER ANALYTICAL DATA
MAY/DECEMBER 1994

VOCs

Twelve individual VOCs, including 1,1,1-TCA, 1,1,2,2-PCA, 1,1-dichloroethane (DCA), 1,2-DCA, chloroform, trans-1,2-DCE, TCE, 1,2-dichlorobenzene, benzene, chlorobenzene, ethylbenzene, and methyl-tert-butyl ether were detected in the May 1994 groundwater samples. No VOCs were detected in concentrations exceeding their respective NREPA PA 451 residential health-based drinking water values. Eighteen of the 21 individual VOC detections were quantified in concentrations less than 1.0 $\mu\text{g/l}$. Only TCE was detected in concentrations greater than 1.0 $\mu\text{g/l}$; wells BC-MW4, BC-MW5, and BC-MW7 contained TCE in concentrations of 2.1, 1.9, and 3.6 $\mu\text{g/l}$, respectively. All concentrations are below the NREPA PA 451 residential health-base drinking water value of 5 $\mu\text{g/l}$.

VOCs detected in the December 1994 sampling event include 1,1,1-TCA, methylene chloride, PCE, and TCE. Well BC-MW16, installed up-gradient of BC-MW4, contained each of these VOCs in concentrations ranging from 0.01 to 4.6 $\mu\text{g/l}$. No VOCs were detected in concentrations exceeding their respective NREPA PA 451 residential health-based drinking water values.

SVOCs

Benzoic acid, di-n-butyl phthalate, and bis (2-ethylhexyl) phthalate were detected in the May 1994 groundwater samples. Benzoic acid was detected in three samples at concentrations ranging from 2 to 4 $\mu\text{g/l}$. Di-n-butyl phthalate was detected in the groundwater sample collected from BC-MW11 at a concentration of 1 $\mu\text{g/l}$, while bis (2-ethylhexyl) phthalate was quantified in eight samples in concentrations ranging from 1 to 41 $\mu\text{g/l}$. This phthalate ester compound was detected in groundwater samples collected from BC-MW12 (22 $\mu\text{g/l}$), BC-MW13 (28.5 $\mu\text{g/l}$), and BC-MW15 (37 $\mu\text{g/l}$) in concentrations which all exceed the NREPA PA 451 residential health-based drinking water criteria value of 6 $\mu\text{g/l}$. However, phthalate esters are common laboratory contaminants. These detections are suspected of being laboratory artifacts.

No SVOCs were detected in groundwater samples collected during December 1994 from wells BC-MW4 and BC-MW16.

Metals

Aluminum, arsenic, barium, calcium, iron, lead, magnesium, manganese, nickel, potassium, sodium, and zinc were detected in the May 1994 filtered groundwater samples which were collected and analyzed from the base boundary wells. The range and frequency of these detections in the May 1994 groundwater data set are included in Table 5-16. Of these metals, aluminum, arsenic, calcium, iron, lead, magnesium, manganese, and potassium were detected in one or more samples at concentrations exceeding either background or the NREPA PA 451 residential health-based drinking water criteria. Arsenic concentrations exceeded background in groundwater samples collected from three base boundary wells, BC-MW4 (9.3 $\mu\text{g/l}$), BC-MW5 (3.4 $\mu\text{g/l}$), and BC-MW15 (4.1 $\mu\text{g/l}$), but are below the NREPA PA 451 residential health-based drinking water criteria value of 50 $\mu\text{g/l}$. Aluminum was detected in eight samples (79.9 $\mu\text{g/l}$ to 166 $\mu\text{g/l}$) in concentrations exceeding background, while iron (five detections-364 to 2,100 $\mu\text{g/l}$) and manganese (one detection-2,220 $\mu\text{g/l}$) were also quantified on concentrations above their respective background. Lead was detected in a concentration above background only in the sample collected from BC-MW11. Metals detected in the December 1994 filtered groundwater samples which were quantified above background include aluminum, calcium, magnesium, and potassium.

Water Quality Parameters

The May 1994 groundwater samples were analyzed for chloride, nitrate, sulfate, and TDS. These data were collected to determine if the trends observed in the January 1992 data have persisted through time. The chloride data are presented on Figure 5-14. Chloride and sodium concentrations show trends similar to the sodium data collected by CDM (June 1992) in January 1992. The concentrations of chloride in the base boundary wells increase from the east (BC-MW1; Chloride = 10 mg/l) to the west (BC-MW5; chloride = 152 mg/l), and then decreases west of BC-MW6 to 5.9 mg/l in the samples collected from BC-MW8. Sulfate and chloride were also sampled from wells BC-MW4 and BC-MW16 in December 1994. Chloride concentrations were higher along the base boundary (BC-MW4; chloride = 60.6 mg/l) when compared to the central portion of the base (BC-MW16; chloride = 44 mg/l).

Table 5-16 Frequency and Range Table Groundwater - Base Boundary Wells
110th FW, MIANG, Battle Creek, Michigan
(May 1994 and December 1994 Data)

	UNITS	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS		BACKGROUND
1,1,1-TRICHLOROETHANE	µg/l	4 / 15	0.03	-	0.52 NA
1,1,2,2-TETRACHLOROETHANE	µg/l	1 / 16	0.35	-	0.35 NA
1,1-DICHLOROETHANE	µg/l	1 / 16	0.19	-	0.19 NA
1,2-DICHLOROETHANE	µg/l	1 / 18	0.28	-	0.28 NA
CHLOROFORM	µg/l	1 / 12	0.06	-	0.06 NA
METHYLENE CHLORIDE	µg/l	1 / 17	0.01	-	0.01 NA
TETRACHLOROETHENE	µg/l	1 / 17	4.6	-	4.6 NA
TRANS-1,2-DICHLOROETHENE	µg/l	2 / 18	0.04	-	0.15 NA
TRICHLOROETHENE	µg/l	6 / 18	0.50	-	3.60 NA
1,2-DICHLOROBENZENE	µg/l	1 / 54	0.03	-	0.03 NA
BENZENE	µg/l	1 / 18	0.04	-	0.04 NA
CHLOROBENZENE	µg/l	2 / 36	0.04	-	0.06 NA
ETHYLBENZENE	µg/l	1 / 18	0.02	-	0.02 NA
METHYL-TERT-BUTYL ETHER	µg/l	3 / 18	0.08	-	0.22 NA
BENZOIC ACID	µg/l	3 / 18	2.00	-	4.00 NA
DI-N-BUTYL PHTHALATE	µg/l	1 / 18	1.00	-	1.00 NA
BIS(2-ETHYLHEXYL)PHTHALATE	µg/l	8 / 18	1.00	-	41.00 NA
ALUMINUM	µg/l	8 / 18	79.9	-	188.00 62.2
ARSENIC	µg/l	3 / 18	3.40	-	9.30 1.3
BARIUM	µg/l	13 / 13	22.40	-	89.70 2400
CALCIUM	µg/l	18 / 18	47300.00	-	109000.00 73850
COPPER	µg/l	2 / 18	3.7	-	4.7 5.0
IRON	µg/l	11 / 18	45.30	-	2100.00 356
LEAD	µg/l	2 / 18	2.00	-	5.00 4
MAGNESIUM	µg/l	18 / 18	8440.00	-	25400.00 14972
MANGANESE	µg/l	10 / 18	5.7	-	2770.00 807
NICKEL	µg/l	1 / 18	48.00	-	48.00 530
POTASSIUM	µg/l	10 / 18	767.00	-	5350.00 1839
SODIUM	µg/l	18 / 18	2040.00	-	67100.00 150000
ZINC	µg/l	8 / 18	2.5	-	68.50 2300
CHLORIDE	mg/l	17 / 18	0.00	-	159.00 NA
SULFATE	mg/l	18 / 18	8.19	-	42.9 NA
DISSOLVED SOLIDS	mg/l	18 / 18	172.00	-	636.00 NA
NITRATE	mg/l	15 / 18	0.4	-	4.0 NA

5.5.3 Base Boundary Wells - Discussion of Results

A brief discussion and interpretation of the analytical results is presented in the following subsections. The groundwater samples collected from the base boundary wells have historically contained relatively low concentrations of VOCs, particularly chlorinated VOCs (i.e., TCE). However, the origin of these VOCs has been unknown.

A review of the existing water quality data contained in the Springfield Wells West of Helmer Technical Memorandum (CDM, June 1992) shows that groundwater containing relatively high concentrations of metals (arsenic and sodium) was being detected in the water table wells down-gradient of the abandoned landfills. These landfills are located immediately across Dickman Road from the northern base boundary. Groundwater flow is from the base (up-gradient), to the landfills, to the MDNR monitoring wells (furthest down-gradient). The presence of arsenic, and sodium, (January 1992) in the base boundary wells could be attributed to the diffusion or dispersion of groundwater contamination located up- or side-gradient to the base boundary wells. Water quality data collected during May 1994 suggests that groundwater containing relatively high concentrations of these metals (arsenic, sodium and chloride) existed along the northern base boundary in May 1994.

Detections of chlorinated VOCs are potentially related to base activities; however, no chlorinated VOCs were present in concentrations exceeding their respective NREPA PA 451 residential health-based drinking water values. Well BC-MW16 was installed up-gradient of the base boundary. The TCE and PCE detected in samples from BC-MW16 suggest the chlorinated VOCs, which have been found historically and are found currently in wells BC-MW4, BC-MW5, and BC-MW6, may have originated from an up-gradient on-base or off-base source.

6.0 DISCUSSION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

6.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

A discussion of the ARARs for the RI are included in the following discussions.

6.1.1 Michigan Environmental Response Act 307 of 1982

The MERA 307, enacted in 1982, provided for the identification, risk assessment, and priority evaluation of environmental contamination in the state of Michigan. MERA 307 of 1982 identified three types of cleanup criteria:

- Type A - Background (or method detection limit)
- Type B - Risk-based with standardized residential exposure assumptions
- Type C - Risk-based with site-specific exposure assumptions.

Legislation passed in 1994 and 1995 has significantly modified the existing MERA 307 regulations regarding the assessment and cleanup of environmental contamination in the state of Michigan.

6.1.2 Michigan Natural Resources and Environmental Protection Act (PA 451)

The Michigan NREPA PA 451, was enacted in 1994. Provisions contained within PA 451 inserted the existing MERA 307 into the newly created NREPA. The pre-existing MERA 307 is now title Part 201 of the NREPA. On June 5, 1995, House Bill 4596, amending Part 201 of the NREPA, was signed into law. These amendments have substantially modified the provisions of the law regarding liability for the cleanup of environmental contamination (MDNR, June 15, 1995). New interim guidance and cleanup standards have been issued by the Environmental Response Division of the MDNR. The MDNR became the Michigan Department of Environmental Quality (MDEQ) during the summer of 1995. The major changes

to the existing guidance and discussions regarding the new guidance is included in the following subsections.

6.1.2.1 General

The three types of cleanup criteria (Type A, Type B, and Type C) which existed under the old MERA 307 have been replaced with four cleanup standard categories:

- residential (formerly Type B)
- commercial (formerly generic Type C criteria)
- recreational
- industrial (formerly generic Type C criteria).

Generic residential, commercial, and industrial chemical-specific cleanup criteria have been developed by the MDNR using standardized exposure and dose assumptions using algorithms developed under current EPA guidance. Exposure assumptions have been developed and used to determine acceptable risk levels for carcinogens (one in one hundred thousand, i.e., 10^{-5}) and for non-carcinogens (Hazard Quotient exceeding 1). Interim guidance published by the MDNR (Operational Memorandum (O.M.) #8, Revision 4, June 5, 1995, and O.M. #14, Revision 2, June 6, 1995) includes chemical-specific cleanup criteria for residential, commercial, and industrial exposures. As of January 1996, generic, chemical-specific recreational cleanup criteria were not available from the MDNR. Background concentrations of metals may be substituted as cleanup goals in cases where background is higher than the applicable generic criteria. The default soil values (Type A) contained in O.M. #15 (MDNR, September 30, 1993) may still be applied as state-wide background values.

General discussions regarding the generic industrial, commercial, and residential exposure assessments, chemical-specific ARARs, and their applicability to this project are presented in the following subsections.

6.1.2.2 Groundwater

Contaminated Groundwater as a Threat to Human Health

Both health-based and aesthetic groundwater values have been developed for residential and industrial/commercial exposure scenarios. Algorithms used to evaluate the exposure scenarios and develop the chemical-specific values are included in O.M. #8, Revision 4, and O.M. #14, Revision 2, copies of which are included in Appendix L. Commercial/industrial values were developed assuming that groundwater beneath a particular facility is used as an on-facility source of drinking water. Inhalation of VOCs released during showering etc., were not evaluated under these exposure scenarios. However, if no significant inhalation risk exists, criteria and/or exposure control measures which are protective for other routes of exposure are deemed protective for the inhalation pathway.

Contaminated Groundwater as a Threat to Surface Water

Groundwater-surface water interface (GSI) values have been developed by the MDNR and represent the maximum allowable hazardous substance concentration at the groundwater-surface water or the edge of the mixing zone, whichever is applicable for a particular site. GSI values are the same for both residential and commercial/industrial exposure scenarios.

6.1.2.3 Soils

Contaminated Soils as a Threat to Groundwater Quality

Procedures and criteria have been developed by the MDNR to evaluate the potential effects contaminated soils have or might have on groundwater beneath a site. Soil action levels judged to be protective of groundwater can be determined through:

- a comparison of measured soil concentration to 20 times (20 ×) the appropriate groundwater criterion (background or the health-based or aesthetic drinking water)

- leachate testing (O.M. #12, Revision 1, September 1994)
- other methods, such as fate and transport modeling.

The $20 \times$ values presented for residential exposure scenarios are provided for convenience and are not mandatory if leachate tests or other methods which better represent in situ conditions support the use of a higher value. Commercial/industrial $20 \times$ values have not been published.

Contaminated Soil as a Threat to Surface Water

Soil action levels judged to be protective of surface water (applying residential exposure scenarios) have been determined by MDNR to be $20 \times$ the appropriate GSI value. Commercial/industrial $20 \times$ values have not been published. However, generic commercial/industrial soil cleanup criteria protective of surface water can be developed using the same approaches that apply to soil criteria protective of groundwater (i.e., leachate testing or modeling).

Contaminated Soil as a Threat to Human Health

Direct contact values have been developed to protect residents or site workers against long-term systematic health effects from ingestion and dermal absorption of hazardous substances in soil. The exposure assumptions used in the algorithms are discussed in O.M. #8, Revision 4, and O.M. #14, Revision 2. Average, on-site soil concentrations, represented by the 95% upper confidence level (UCL) on the arithmetic mean, may be used to determine compliance with the soil direct contact values. Note that exposures through inhalation of VOCs released from the soils or inhalation of particulate contaminant emissions are excluded from the direct contact values. However, if no significant inhalation risk exists, criteria and/or exposure control measures which are protective for other routes of exposure and deemed protective for the inhalation pathway.

7.0 SIGNIFICANCE OF RESULTS

The following sections discuss the results and the significance of the results for the risk characterization which has been prepared for Site 1 and the base boundary wells. No risk characterization is presented for Site 3.

The current NREPA PA 451 cleanup criteria (commercial/industrial and residential) are chemical-specific, risk-based cleanup values. Where applicable, this risk characterization incorporates the generic evaluations developed by the MDNR. Where no applicable criteria exist, a site-specific risk assessment is developed.

Section 7.1 describes the rationale used to develop the final data set for use in the risk characterization. Sections 7.2 and 7.3 present the risk characterization for Site 1 (including the environmental assessment) and the base boundary wells.

7.1 RATIONALE FOR DEVELOPMENT OF DATABASE FOR RISK CHARACTERIZATION

Chemicals of potential concern were initially selected on a site-specific basis based on NREPA PA 451 industrial (for soil exposures) or residential (for groundwater exposures) cleanup criteria. The methodology for development of these data sets is outlined below.

All data excluding the AOC B soils and additional Site 1 metals data were validated according to EPA Functional Guidelines for Evaluating Organic and Inorganic Analyses (EPA, June 1992b, 1988a). The validation is presented in Appendix F. Samples were evaluated using the five and ten times rule for laboratory blank contamination. Field blank data were not included under the five and ten times rule for blank contamination. Those data found to be laboratory artifacts were qualified with a "B", indicating blank contamination, and were not included in the database.

Soil

The background and Site 1/AOC B soils data collected during the summer and fall of 1994 were used in the selection of chemicals of concern. All organic and inorganic compounds detected within the data set which have been evaluated and included by the MDNR in their published guidance were selected as chemicals of potential concern.

In generating the final data set (i.e., development of 95% UCLs) those chemicals of concern which were non-detect (qualified "U") in a given sample were assigned a value of one-half of the sample quantitation limit (SQL). Duplicate sample results were averaged with the original sample results and the average value used as a single sample result.

Groundwater

Groundwater analytical data collected by EARTH TECH field personnel during May 1994, November/December 1994, and May 1995 were used to select chemicals of potential concern. All organic compounds detected in the data set which have been evaluated and included by the MDNR in their published guidance were selected as chemicals of potential concern. Filtered groundwater data were used to select inorganic chemicals of potential concern. Duplicate sample results were averaged with the original sample results and the average value used as a single sample result.

7.2 SITE 1: FUEL TANK FARM/AREA OF CONCERN B: MOTOR POOL DRAINAGE DITCH RISK CHARACTERIZATION

The risk characterization for Site 1: Fuel Tank Farm/Area of Concern B: Motor Pool Drainage Ditch Area was completed to estimate the health risk for human receptors.

Section 7.2.1 identifies the chemicals of potential concern in the Site 1/AOC B soils and groundwater. Section 7.2.2 presents an exposure assessment for human receptors. The risk characterization is presented in Section 7.2.3, including an evaluation of contaminated soils

as a threat to groundwater. A discussion of the site-specific ecological risk is included in Section 7.2.4.

7.2.1 Identification of Chemicals of Potential Concern

Chemicals of potential concern at Site 1 / AOC B were selected for the soils and groundwater by comparing the chemicals detected within the surface and subsurface soils and groundwater to the full list of chemicals regulated under NREPA PA 451. This comparison is presented in Table 7-1. Any chemical detected at Site 1 / AOC B which is not listed in the NREPA PA 451 guidance was not retained as a chemical of potential concern.

7.2.2 Exposure Assessment

The purpose of the exposure assessment is to estimate the type and magnitude of human receptor exposure to chemicals of potential concern resulting from Site 1 /AOC B activities. The following exposure assessment components are evaluated in this section:

- Characterization of the exposure setting
- Identification of exposure pathways/receptors
- Estimation of chemical concentrations at receptors

7.2.2.1 Characterization of the Exposure Setting

Based on guidance contained in MDNR O.M. #14, Revision 2 (June 6, 1995), the base qualifies as an industrial site: the base and the surrounding airport property are zoned L1 light industrial (personnel communication, 110th FG Environmental Coordinator to EARTH TECH, January 31, 1995). The MIANG leases the land from the state of Michigan and this lease is valid until the year 2038 (Personal communication, 110th FG Environmental Coordinator to EARTH TECH, January 31, 1995). The primary activities on the base (aircraft flight operations and maintenance) are industrial in nature.

Table 7-1 Selection of Chemicals of Potential Concern Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan

ANALYTE	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER	REGULATED UNDER NREPA PA 451 (a)
Acetone	X	X		Yes
Benzene			X	Yes
1,3-Dichlorobenzene			X	Yes
1,4-Dichlorobenzene			X	Yes
Ethylbenzene		X	X	Yes
Methylene chloride			X	Yes
Tetrachloroethene	X			Yes
Toluene			X	Yes
Xylenes (m-,p-,o-, or total)		X	X	Yes (b)
Acenaphthene	X			Yes
Acenaphthylene	X			Yes
Anthracene	X			Yes
Benzo(a)anthracene	X			Yes
Benzo(a)pyrene	X			Yes
Benzo(b)fluoranthene	X			Yes
Benzo(g,h,i)perylene	X			Yes
Benzo(k)fluoranthene	X			Yes
Carbazole	X			No
Chrysene	X			Yes
Di-n-butyl phthalate	X	X	X	Yes
Dibenzo(a,h)anthracene	X			Yes
Dibenzofuran	X	X		Yes (c)
Fluoranthene	X			Yes
Fluorene	X	X		Yes
Indeno(1,2,3-cd)pyrene	X			Yes
2-Methylnaphthalene	X	X	X	Yes (c)
Naphthalene	X	X	X	Yes
Phenanthrene	X	X		Yes
Phenol		X		Yes
Pyrene	X			Yes
bis(2-Ethylhexyl)phthalate	X	X		Yes
Aluminum(d)			X	Yes

Table 7-1 Selection of Chemicals of Potential Concern Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan
(continued)

ANALYTE	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER	REGULATED UNDER NREPA PA 451 (a)
Antimony	X	X		Yes
Arsenic	X	X		Yes
Barium	X	X	X	Yes
Beryllium	X	X		Yes
Cadmium	X	X		Yes
Calcium (d)			X	No
Chromium, total	X	X		Yes
Chromium, + 6 valence(e)	X			Yes
Cobalt (d)			X	Yes
Copper	X	X	X	Yes
Iron (d)			X	Yes
Lead	X	X	X	Yes
Magnesium (d)			X	No
Manganese(d)			X	Yes
Nickel	X	X	X	Yes
Potassium (d)			X	No
Selenium	X	X		Yes
Silver	X	X		Yes
Sodium(d)			X	Yes
Thallium	X			Yes
Vanadium (d)			X	Yes
Zinc	X	X	X	Yes

(a) Sources - MDNR O.M. #14, Revision 2 (June 6, 1995) and O.M. #8, Revision 4 (June 5, 1995)

(b) Considered as total xylenes under NREPA PA 451 guidance

(c) Although listed in the NREPA PA 451, the guidance states that inadequate data is available to develop a cleanup criteria for this analyte. This analyte will not be considered further in the risk assessment.

(d) Not analyzed for in the soils

(e) Analyzed for only in AOC B soils.

A chain-link security fence surrounds the property. The public can only enter and exit the base through the main gate. Site 1/AOC B lies within the fenced in area (Figure 2-2), and was the site of fuel and waste-handling activities as described in Section 2.3. Site 1/ AOC B is grass-covered. This vegetative cover prevents fugitive dust from being generated at the site. Areas adjacent to the site are grass-, or asphalt-covered.

Groundwater contained in the shallow aquifer beneath Site 1/AOC B is found at an average depth of 25 ft bgs. Groundwater flows north/northwest beneath the site. Groundwater contaminants are restricted to the site; groundwater analytical results show that the hydrocarbons which exist in the groundwater have not migrated past the BC2-MW1/BC1-MW3 well pair which is located immediately down-gradient of the site. The nearest surface water body down-gradient of Site 1/AOC B is the Kalamazoo River, which is located approximately 1.5 miles north of the base.

The base obtains its drinking water from the city of Battle Creek, Michigan. The nearest, down-gradient, off-site residential wells lie approximately one mile to the north of the northern base boundary. Site 1/AOC B is located approximately 250 ft south of the northern base boundary.

7.2.2.2 Identification of Exposure Pathways/Receptors

The property was not in use at the time this report was prepared. Base personnel who are periodically in contact with the soils at Site 1/ AOC B are the grounds maintenance people and ANG personnel who may be on-base for training one weekend per month.

The following potential current exposure pathways and receptors we evaluated:

- Incidental ingestion of contaminated soil by base personnel
- Dermal contact with contaminated soils by base personnel.

The inhalation of fugitive dust by base personnel is not evaluated as a current exposure pathway because the vegetative cover at Site 1/AOC B prevents fugitive dust from being generated at the site.

Groundwater is not used at the base, therefore no on-site groundwater exposure pathways are complete. Groundwater contaminants are apparently restricted to the site; therefore, no off-site exposure pathways are complete.

Future residential land use of the site is highly improbable due to its location at the airport. The most likely alternate future land use for the property is light industrial or commercial. In the future, the ANG may initiate construction activities on the property. During excavation or construction activities, workers may be exposed to contaminants through soil ingestion, dermal contact with soil and inhalation of fugitive dust. Groundwater contained within the shallow aquifer is not used by the base and is not anticipated to be needed as an on-base source of potable water. However, use of this water is not prohibited. Contaminated groundwater may migrate north/northwest (down-gradient) past Site 1 and leave the base. The future off-site domestic use of this groundwater is considered a potential exposure pathway.

The following exposure pathways and receptors are evaluated under the future land use scenario:

- Future incidental ingestion of contaminated soil by construction workers
- Future dermal contact with contaminated soils by construction workers
- Future inhalation of fugitive dust containing contaminated soil by construction workers
- Future ingestion of contaminated groundwater from shallow aquifer production wells (on-site) by base personnel

- Future ingestion of contaminated groundwater from down-gradient shallow aquifer production wells (off-site) by adults and children.

Table 7-2 summarizes the current and future exposure pathways which are considered complete. In addition, Table 7-2 lists the criteria used to evaluate each pathway.

**Table 7-2 Current and Future Exposure Pathways - Site 1
110th FW, MIANG, Battle Creek, Michigan**

Receptor Population	Exposure Point	Exposure Pathway	Evaluation Criteria
Current Land Use			
Base Personnel	on-site	Dermal contact with and incidental ingestion of contaminated soil	NREPA PA 451 - generic industrial cleanup criteria
Future Land Use			
Excavation Worker	on-site	Future incidental ingestion of contaminated soil.	NREPA PA 451 - site-specific assessment
Excavation Worker	on-site	Future dermal contact with contaminated soil.	NREPA PA 451 - site-specific assessment
Excavation Worker	on-site	Inhalation of fugitive dust	NREPA PA 451 - site-specific assessment
Base Personnel	on-site	Future ingestion of contaminated groundwater from shallow aquifer production wells	NREPA PA 451 - generic industrial cleanup criteria
Adult and Child	off-site	Future ingestion of contaminated groundwater from shallow aquifer production wells	NREPA PA 451 - cleanup criteria

7.2.2.3 Estimation of Chemical Concentrations at Receptors

Average on-site soil concentrations, represented as a 95% UCL on the arithmetic mean, were calculated. The goodness-of-fit of the data was checked using the Shapiro-Wilk test (Equation 1). If the Shapiro-Wilk test demonstrated that the data were not lognormally distributed, Equation 2 was used to calculate the 95% UCL, if the data were lognormally distributed, Equation 3 was used to calculate the 95% UCL. All equations used are detailed in *Statistical Methods for Environmental Pollution Monitoring*, R.O. Gilbert, Von Nostrand Reinhold, 1987.

Equation 1

$$W = \frac{1}{d} \left[\sum_{i=1}^k a_i (x_{[n-1+1]} - x_{[i]}) \right]^2$$

Where

$$d = \sum_{i=1}^n (x_i - \bar{x})^2$$

$$k = \frac{n}{2} \quad \text{if } n \text{ is even}$$

$$k = \frac{n-1}{2} \quad \text{if } n \text{ is odd}$$

Equation 2

$$UCL_{95} = \bar{x} + t_{0.95, n-1} \left(\frac{s}{\sqrt{n}} \right)$$

x Arithmetic mean of the analyte concentrations

t_{0.95, n-1} 95 percent t distribution value for n-1 degrees of freedom

s Standard deviation

n Number of contaminant samples

Equation 3

$$UCL_{95} = \exp \left(\bar{x} + 0.5s^2 + \frac{sH}{\sqrt{n-1}} \right)$$

exp Base of natural log, approximately equal to 2.718

x Arithmetic mean of the natural logarithms of the analyte concentrations

s Standard deviation

H H-statistic

n Number of contaminant samples

Ninety-five percent UCLs were not calculated for the groundwater data. The pre-existing MERA 307 guidance (O.M. #8, Revision 3, February 4, 1994) states that the point of

exposure for groundwater can be any point in the aquifer, and there is no discussion in the NREPA PA 451 guidance suggesting that this criteria has changed. The groundwater analytical data were therefore compared directly to the existing NREPA PA 451 residential or industrial health-based drinking water values chemical-specific criteria.

7.2.3 Risk Characterization

The risk characterizations for the current and future exposure pathways/receptors identified in Section 7.2.2.2 are included in the following subsections.

7.2.3.1 Current Exposure Pathways - Soils

The soil data set for the current exposure pathways contains all samples presented in Table 5-7; similarly, the subsurface soil data set contains all samples presented in Table 5-8.

Dermal Contact and Ingestion of Contaminated Soil

As stated in the characterization of the exposure setting (Section 7.2.2.1) the base and the surrounding property are located in an industrial setting. Summaries of the exposure assessments used to develop the NREPA PA 451 generic industrial cleanup criteria (O.M #14, Revision 2, June 6, 1995) were reviewed during this risk characterization to determine their applicability to this RI. The generic industrial exposure scenarios were judged to provide a worst-case evaluation of the exposure concentrations base personnel would receive from the Site 1/ AOC B soils. Copies of the guidance document containing the generic industrial cleanup criteria are included in Appendix L.

Exposure via the dermal absorption and incidental ingestion of soils pathways were combined by the MDNR to develop the generic industrial direct contact to soils generic industrial cleanup criteria. A comparison of the generic industrial cleanup criteria to the 95% UCLs for the chemicals of potential concern contained in both the surface and subsurface soils is presented in Tables 7-3 and 7-4.

Table 7-3
Risk Characterization-Site 1/AOC B
Direct Contact to Surface Soils by Base Personnel
110th FW, MIANG, Battle Creek, Michigan

	DISTRIBUTION (Log normal = Yes)	MEAN	95 % UCL	NREPA PA 451 GENERIC INDUSTRIAL DIRECT CONTACT VALUE ^(a)
Acetone	No	6.67	8.15	74,000,000
Tetrachloroethene	No	3.31	3.87	49,000
Acenaphthene	No	230.42	264.52	810,000,000
Acenaphthylene	No	200.74	240.78	16,000,000
Anthracene	Yes	178.63	277.69	1,000,000,000
Benzo(a)anthracene	Yes	357.63	630.67	210,000
Benzo(a)pyrene	Yes	357.08	603.28	21,000
Benzo(b)fluoranthene	Yes	546.74	1021.52	210,000
Benzo(g,h,i)perylene	Yes	253.45	337.73	16,000,000
Benzo(k)fluoranthene	Yes	616.24	1179.82	2,100,000
Chrysene	Yes	360.47	615.59	21,000,000
Di-n-butyl phthalate	No	140.79	186.72	540,000,000
Dibenzo(a,h)anthracene	No	196.63	237.95	21,000
Fluoranthene	Yes	469.58	844.43	540,000,000
Fluorene	No	201.26	242.62	540,000,000
Indeno(1,2,3-cd)pyrene	Yes	269.97	353.18	210,000
Naphthalene	No	216.58	249.43	160,000,000
Phenanthrene	Yes	279.50	418.15	16,000,000
Pyrene	Yes	430.13	729.04	340,000,000
bis(2-Ethylhexyl)phthalate	No	215.32	250.63	11,000,000
Antimony	No	0.52	0.86	1,600
Arsenic	Yes	6.89	8.78	83
Barium	Yes	32.24	42.06	320,000
Beryllium	No	0.22	0.25	35
Cadmium	No	0.20	0.44	2,300
Chromium ^(b)	No	12.19	16.77	1,000,000
Copper	No	9.24	11.19	170,000
Lead	No	197.55	482.56	400
Nickel	No	8.28	9.26	340,000
Selenium	No	0.33	0.43	23,000
Silver	No	0.22	0.38	21,000
Thallium	No	0.21	0.28	300
Zinc	No	35.26	50.65	1,000,000

(a) Michigan Department of Natural Resources Operational Memorandum 14 version 2 (June 6, 1995).

(b) Chromium⁺⁶ data are available for BSB1 through BSB4 (SI data); no chromium⁺⁶ was detected; therefore, all chromium was evaluated as chromium⁺³.

ID Insufficient data to develop a criteria

-- Analyte not detected during analysis

Organic compounds are presented in units of $\mu\text{g}/\text{kg}$

Inorganic compounds are presented in units of mg/kg

**Table 7-4 Risk Characterization-Site 1/AOC B
Direct Contact to Subsurface Soils by Base Personnel
110th FW, MIANG, Battle Creek, Michigan**

	DISTRIBUTION (Log normal = Yes)	MEAN	95 % UCL	NREPA PA 451 GENERIC INDUSTRIAL DIRECT CONTACT VALUE ^(a)
Acetone	No	13.08	20.35	74,000,000
Ethylbenzene	No	3.30	3.67	72,000,000
Xylenes (Total)	No	7.39	7.94	1,000,000,000
Di-n-butyl phthalate	No	364.30	759.50	540,000,000
Fluorene	No	463.73	966.70	540,000,000
Naphthalene	No	637.27	1404.89	160,000,000
Phenanthrene	No	614.36	1375.43	16,000,000
Phenol	No	383.41	737.22	450,000,000
bis(2-Ethylhexyl)phthalate	No	408.27	763.46	11,000,000
Antimony	No	0.82	1.33	1,600
Arsenic	Yes	5.50	7.74	83
Barium	Yes	16.33	22.27	320,000
Beryllium	Yes	0.12	0.14	35
Cadmium	No	0.06	0.09	2,300
Chromium ^(b)	No	21.04	42.13	1,000,000
Copper	No	5.99	7.22	170,000
Lead	Yes	4.02	4.75	400
Mercury ^(c)	No	0.06	0.10	1,400
Nickel	Yes	12.60	17.76	340,000
Selenium	No	0.23	0.29	23,000
Silver	No	0.08	0.11	21,000
Zinc	Yes	16.16	18.49	1,000,000

(a) Michigan Department of Natural Resources Operational Memorandum 14 version 2 (June 6, 1995).

(b) Chromium⁺⁶ data are available for BSB1 through BSB4 (SI data); no chromium⁺⁶ was detected; therefore, all chromium was evaluated as chromium⁺³.

(c) Mercury results were available only for borings BSB1 through BSB4 and BC1MW1.

ID Insufficient data to develop a criteria

-- Analyte not detected during analysis

Organic compounds are presented in units of µg/kg

Inorganic compounds are presented in units of mg/kg

The reasonable maximum lead concentration (as represented by the 95% UCLs) present in the surface soils exceeds the NREPA PA 451 generic industrial cleanup criteria. The other chemicals of potential concern contained within the Site 1/AOC B surface and subsurface soils are not present in reasonable maximum concentrations exceeding the NREPA PA 451 generic industrial cleanup criteria.

Lead was detected in the surface soil sample collected from location 1SB12 at a concentration of 3,150 mg/kg. This concentration is significantly above the next highest lead concentration of 200 mg/kg. If exposure to the surface soils encompassing location 1SB12 could be mitigated, the lead remaining in the surface soils would have a 95% UCL of 54 mg/kg, which is below the generic industrial cleanup criteria of 400 mg/kg for lead.

7.2.3.2 Future Exposure Pathways - Soils

Future exposure pathways which are considered complete for the construction worker are incidental ingestion of contaminated soil, dermal contact with contaminated soil, and inhalation of contaminated fugitive dust. No NREPA PA 451 cleanup criteria exists for construction worker scenarios, therefore, a baseline risk assessment is performed in accordance with the *Risk Assessment Guidance for Superfund Volume 1*, EPA, December 1989, and supplemental guidance for Volume 1 (EPA, March 1991).

Exposure to soil from 0 to 12 ft bgs is evaluated. All organic compounds regulated by NREPA PA 451 were included in the evaluation. Ninety-five percent UCLs for soils from 0 to 12 ft are presented in Appendix M. Only metals which were detected in surface or subsurface soils in concentrations exceeding background are included in the risk assessment. Subchronic daily intake values are estimated for the pathways identified above. The formulas and assumptions used to model the intake values for each exposure pathway are presented in Tables 7-5 through 7-7. The intake values are presented in Appendix M. The toxicity values for carcinogenic and noncarcinogenic effects of the chemicals of concern are also presented in Appendix M.

**Table 7-5 Model for Estimating Future Chemical Absorbed Dose
by Adults through Dermal Contact with Chemicals in Soil - Site 1**
110th FW, MIANG, Battle Creek, Michigan

$$AbsorbedDose \text{ (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

- CS = Chemical Concentration in Soil (mg/kg) (0- 12 ft below land surface)
- CF = Conversion Factor (10^{-6} kg/mg)
- SA = Skin Surface Area Available for Contact (cm^2/event)
- AF = Soil to Skin Adherence Factor (mg/cm^2)
- ABS = Absorption Factor (unitless)
- EF = Exposure Frequency (days/years)
- ED = Exposure Duration (years)
- BW = Body Weight (kg)
- AT = Averaging Time (period over which exposure is averaged, in days).

	Future Construction Worker
Assumptions:	
Surface area (cm^2/day)	2,570 ¹
Soil to Skin Adherence Factor (mg/cm^2)	1 ¹
Absorption Factor	.01 0.25
Exposure Frequency (days/yr)	250
Exposure Duration (years)	.25 ²
Body Weight (kg)	70 ³
Averaging Time (year)	.25

Notes:

- 1) MERA 307 default values (1990)
- 2) Exposure during construction occurs for three months.
- 3) U.S. Environmental Protection Agency, 1991.

**Table 7-6 Model for Estimating Future Chemical Intake by Adults
through Ingestion of Chemicals in Soil - Site 1**
110th FW, MIANG, Battle Creek, Michigan

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where:

- CS = Chemical Concentration in Soil (mg/kg) (0-12 ft below land surface)
- IR = Ingestion rate (mg/day)
- CF = Conversion Factor (10^{-6} kg/mg)
- FI = Fraction Ingested from Contaminated Source (unitless)
- EF = Exposure Frequency (days/years)
- ED = Exposure Duration (years)
- BW = Body Weight (kg)
- AT = Averaging Time (period over which exposure is averaged, in days).

	Future Construction Worker
Assumptions:	
Ingestion Rate (IR) (mg/day)	480
Fraction Ingested	1
Exposure Frequency (days/yr)	250
Age Group (year)	16-65
Exposure Duration (years)	.25
Body Weight (kg)	70
Averaging Time (years)	.25

Notes:

- 1) All values from U.S. Environmental Protection Agency, 1991.
- 2) Assumes three month exposure for construction activities.

**Table 7-7 Model for Estimating Future Intake by Adults
through Inhalation of Particulates from Chemicals in Soil - Site 1
110th FW, MIANG, Battle Creek, Michigan**

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

where:

CA	=	Contaminant Concentration in Air (mg/m ³)
IR	=	Inhalation Rate (m ³ /hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (period over which exposure is averaged, in days).

	Future Construction Worker
Inhalation Rate (m ³ /hr)	20
Exposure Time (hrs/day) ²	8
Exposure Frequency (days/yr)	250
Exposure Duration (years)	0.25
Body Weight (kg)	70
Averaging Time (years)	
Carcinogens	70
Noncarcinogens	0.25

Notes:

- 1) All values from U.S. Environmental Protection Agency, 1991.
- 2) Future excavation activities are on going for 3 months

The contaminant concentration in air is calculated using the initial contaminant concentration in the soil and emission factors for vehicles and excavation equipment.

**Table 7-7 Model for Estimating Future Intake by Adults
through Inhalation of Particulates from Chemicals - Site 1 (Continued)**
110th FW, MIANG, Battle Creek, Michigan

The amount of dust made airborne by excavation/dumping activities is calculated with the following model (EPA, 1983)

$$E = 0.009 k \frac{(s / 5) (u / 2.2) (H / 15)}{(M / 2)^2 (Y / 4.6)^{0.33}}$$

where

E	=	emission factor (kg/metric ton loaded)
K	=	particle size multiplier. (=0.36)
s	=	silt content in soil, % (=2)
u	=	mean wind speed (m/s) (=2)
H	=	drop height (m) (=2)
M	=	soil moisture content % (=15)
Y	=	dumping device capacity (cubic yd) (=2)

The emission rate for each contaminant was calculated as:

$$E_R = E \cdot W_i / W \cdot \text{bulk density} \cdot Q/A$$

E	=	emission factor (kg dust/kg soil loaded)
W _i /W	=	Weight fraction of chemical i, (g/g)
bulk density	=	bulk density (estimated at 3.5 g/cm ³)
Q	=	volume of soil removed in time t, cm ³ /sec
A	=	area of soil removed in time t

The SCREEN2 model was used to develop a maximum average dilution factor. This dilution factor was then multiplied by the emission rate for each contaminant to obtain an average concentration.

For the carcinogenic risk estimate, calculated risk values are compared to the EPA recommended benchmark of 10^{-6} . Non-carcinogenic hazard indices are compared to unity, per EPA guidance. All risk calculations are presented in Appendix M. A summary of the carcinogenic risk estimates for the construction worker is presented in Table 7-8. Table 7-9 presents a summary of the non-carcinogenic hazard index.

The total carcinogenic risk estimate for the future construction worker exceeds the benchmark of 10^{-6} , indicating an unacceptable probability of risk. Inhalation of fugitive dust exceeds the reference level but is the same order of magnitude, and approximately 80% of the risk from inhalation of fugitive dust is attributable to arsenic.

The total hazard index estimate for the future construction worker is less than unity. A value less than unity indicates a low potential for adverse noncarcinogenic health affects.

The uncertainties involved in the process of quantifying risk for the construction worker include uncertainties in the exposure assessment, the toxicity assessment, and the risk estimation. Uncertainties in the exposure assessment include the assumption that the chemical concentrations at the site are assumed to remain constant over time and are assumed to be uniformly distributed over the defined areas. These assumptions tend to overestimate the exposure point concentrations. The air emissions model used is a worst-case evaluation and likely overestimates the ambient air concentrations. The reference dose values developed by the EPA are considered to have uncertainty spanning an order of magnitude or more. Slope factors are generally conservative and likely overestimate the risk.

7.2.3.3 Current Exposure Pathways - Groundwater

There are no current groundwater users on the base. Groundwater contaminants associated with the release of heating oil constituents have not migrated past the northern boundary of Site 1 in concentrations exceeding the NREPA PA 451 residential health-based drinking water criteria. No groundwater data were collected for AOC B.

**Table 7-8 Estimate of Future Carcinogenic Effects
for Construction Worker-Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan**

Chemical	Chemical-specific Carcinogenic Risk	Total Pathway Carcinogenic Risk	Total Exposure Carcinogenic Risk
Exposure Pathway: Dermal contact with soil			
2-Methylnaphthalene	OE + 00		
Acetone	OE + 00		
Acenaphthene	OE + 00		
Acenaphthylene	OE + 00		
Antimony	OE + 00		
Anthracene	OE + 00		
Arsenic	1E-08		
Benzo(a)anthracene	4E-08		
Benzo(a)pyrene	4E-07		
Benzo(b)flouranthene	5E-08		
Benzo(k)fluoranthene	1E-06		
Benzo(g,h,i)perylene	3E-08		
Beryllium	8E-08		
bis (2-ethylhexyl) phthalate	2E-09		
Carbazole	2E-07		
Chrysene	2E-10		
Dibenz(a,h)anthracene	2E-07		
Di-n-butyl phthalate	OE + 00		
Dibenzofuran	2E-07		
Fluoranthene	OE + 00		
Fluorene	OE + 00		
Indeno(1,2,3-cd)pyrene	2E-07		
Naphthalene	OE + 00		
Phenanthrene	2E-09		
Phenol	OE + 00		
Pyrene	OE + 00		
Tetrachloroethene	4E-12		
Subtotal		2 × 10 ⁻⁶	
Exposure Pathway: Ingestion of soil			
2-Methylnaphthalene	OE + 00		
Acetone	OE + 00		
Acenaphthene	OE + 00		
Acenaphthylene	OE + 00		
Antimony	OE + 00		
Anthracene	OE + 00		
Arsenic	2E-07		
Benzo(a)anthracene	4E-09		
Benzo(a)pyrene	4E-08		
Benzo(b)flouranthene	7E-09		
Benzo(k)fluoranthene	8E-08		
Benzo(g,h,i)perylene	3E-09		
Beryllium	2E-08		
bis (2-ethylhexyl) phthalate	3E-10		
Carbozole	3E-08		
Chrysene	1E-10		
Dibenz(a,h)anthracene	3E-08		
Di-n-butyl phthalate	OE + 00		

**Table 7-8 Estimate of Future Carcinogenic Effects
for Construction Worker-Site 1/AOC B (continued)
110th FW, MIANG, Battle Creek, Michigan**

Chemical	Chemical-specific Carcinogenic Risk	Total Pathway Carcinogenic Risk	Total Exposure Carcinogenic Risk
Dibenzofuran	3E-08		
Fluoranthene	0E + 00		
Fluorene	0E + 00		
Indeno(1,2,3-cd)pyrene	2E-08		
Naphthalene	0E + 00		
Phenanthrene	2E-10		
Phenol	0E + 00		
Pyrene	0E + 00		
Tetrachloroethene	3E-12		
Subtotal		5 × 10 ⁻⁷	
Exposure Pathway: Inhalation of fugitive dust			
2-Methylnaphthalene	0E + 00		
Acetone	0E + 00		
Acenaphthene	0E + 00		
Acenaphthylene	0E + 00		
Antimony	0E + 00		
Anthracene	0E + 00		
Arsenic	4E-06		
Benzo(a)anthracene	1E-07		
Benzo(a)pyrene	1E-07		
Benzo(b)flouranthene	2E-07		
Benzo(k)fluoranthene	2E-07		
Benzo(g,h,i)perylene	0E + 00		
Beryllium	7E-08		
bis (2-ethylhexyl) phthalate	1E-10		
Carbazole	2E-10		
Chrysene	1E-07		
Dibenz(a,h)anthracene	0E + 00		
Di-n-butyl phthalate	0E + 00		
Dibenzofuran	0E + 00		
Fluoranthene	0E + 00		
Fluorene	0E + 00		
Indeno(1,2,3-cd)pyrene	8E-08		
Naphthalene	0E + 00		
Phenanthrene	0E + 00		
Phenol	0E + 00		
Pyrene	0E + 00		
Tetrachloroethene	2E-13		
Subtotal		5E-06	
Excavation Worker - Total			
			7 × 10 ⁻⁶

**Table 7-9 Estimate of Future Noncarcinogenic Effects
for the Construction Worker-Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan**

Chemical	Chemical-specific Hazard Quotient	Total Pathway Hazard Index	Total Exposure Hazard Index
Exposure Pathway: Dermal contact with soil			
2-Methylnaphthalene	3E-05		
Acetone	1E-07		
Acenaphthene	1E-05		
Acenaphthylene	0		
Antimony	1E-02		
Anthracene	3E-06		
Arsenic	7E-05		
Benzo(a)anthracene	4E-05		
Benzo(a)pyrene	4E-05		
Benzo(b)flouranthene	7E-05		
Benzo(k)fluoranthene	8E-05		
Benzo(g,h,i)perylene	3E-05		
Beryllium	1E-03		
bis (2-ethylhexyl) phthalate	4E-04		
Carbazole	0		
Chrysene	1E-05		
Dibenz(a,h)anthracene	3E-05		
Di-n-butyl phthalate	1E-06		
Dibenzofuran	0		
Fluoranthene	4E-05		
Fluorene	2E-05		
Indeno(1,2,3-cd)pyrene	3E-05		
Naphthalene	3E-05		
Phenanthrene	4E-05		
Phenol	5E-06		
Pyrene	4E-05		
Tetrachloroethene	2E-07		
Subtotal		2E-02	
Exposure Pathway: Ingestion of soil			
2-Methylnaphthalene	3E-06		
Acetone	7E-08		
Acenaphthene	2E-06		
Acenaphthylene	0		
Antimony	1E-02		
Anthracene	3E-07		
Arsenic	1E-01		
Benzo(a)anthracene	6E-06		
Benzo(a)pyrene	6E-06		
Benzo(b)flouranthene	9E-06		
Benzo(k)fluoranthene	1E-05		
Benzo(g,h,i)perylene	4E-06		
Beryllium	2E-04		
bis (2-ethylhexyl) phthalate	6E-05		
Carbozole	0		
Chrysene	6E-06		
Dibenz(a,h)anthracene	3E-06		
Di-n-butyl phthalate	1E-06		

**Table 7-9 Estimate of Future Noncarcinogenic Effects
for Construction Worker-Site 1/AOC B (continued)
110th FW, MIANG, Battle Creek, Michigan**

Chemical	Chemical-specific Hazard Quotient	Total Pathway Hazard Index	Total Exposure Hazard Index
Dibenzofuran	0E + 00		
Fluoranthene	6E-06		
Fluorene	3E-06		
Indeno(1,2,3-cd)pyrene	4E-06		
Naphthalene	4E-06		
Phenanthrene	5E-06		
Phenol	4E-06		
Pyrene	7E-06		
Tetrachloroethene	2E-07		
Subtotal		1E-01	
Exposure Pathway: Inhalation of fugitive dust			
2-Methylnaphthalene	8E-06		
Acetone	3E-04		
Acenaphthene	6E-03		
Acenaphthylene	8E-03		
Antimony	4E-05		
Anthracene	7E-06		
Arsenic	3E-04		
Benzo(a)anthracene	1E-05		
Benzo(a)pyrene	8E-03		
Benzo(b)flouranthene	4E-04		
Benzo(k)fluoranthene	2E-05		
Benzo(g,h,i)perylene	9E-06		
Beryllium	5E-04		
bis (2-ethylhexyl) phthalate	4E-03		
Carbazole	8E-06		
Chrysene	0		
Dibenz(a,h)anthracene	8E-06		
Di-n-butyl phthalate	2E-06		
Dibenzofuran	0		
Fluoranthene	9E-03		
Fluorene	4E-03		
Indeno(1,2,3-cd)pyrene	1E-05		
Naphthalene	4E-03		
Phenanthrene	5E-03		
Phenol	4E-06		
Pyrene	8E-03		
Tetrachloroethene	4E-07		
Subtotal		6E-02	
Excavation Worker - Total			2E-01

7.2.3.4 Future Exposure Pathways - Groundwater

On-site Groundwater Use

Future groundwater use at Site 1 by base personnel was evaluated by comparing the chemicals of potential concern detected in the Site 1 groundwater samples to the NREPA PA 451 generic industrial health-based drinking water values. NREPA PA 451 generic industrial cleanup criteria have been developed to protect workers whose drinking water is obtained from an on-site source. The range of chemicals of potential concern in the Site 1 groundwater analyses are presented in Table 7-10 along with the NREPA PA 451 generic health-based drinking water criteria. No organic compounds were present within the site groundwater samples in concentrations which exceed the NREPA PA 451 generic health-based drinking water values. Arsenic and iron were, however, quantified in concentrations exceeding these drinking water values. Based on this evaluation, the groundwater beneath Site 1 should be excluded as a potential future source of on-base potable water.

Off-site Groundwater Use

In the future, the chemicals of potential concern detected within the Site 1 groundwater will migrate to the northwest, eventually leaving the base. Fate and transport modelling was not completed for the Site 1 groundwater as part of this risk characterization. A worst-case scenario evaluating future off-site exposures is presented in the following discussions. This evaluation assumes that future off-site concentrations of chemicals of potential concern will be equal to the current concentrations of chemicals of potential concern detected within the Site 1 groundwater. Under this scenario, the concentrations of chemicals of potential concern are compared to the residential health-based drinking water values (MDNR O.M. #8, revision 4, June 6, 1995). This comparison is presented in Table 7-11. As shown in Table 7-11, phenanthrene, arsenic, and iron were detected within the Site 1 groundwater data set in concentrations which exceed their respective residential health-based drinking water criteria. However, due to the combined effects of dispersion, diffusion, and biodegradation (for organic compounds) it is highly unlikely that these compounds will reach the base boundary (located

Table 7-10 Risk Characterization - Site 1
Future On-Site Ingestion of Groundwater by Base Personnel
110th FW, MIANG, Battle Creek, Michigan

ANALYTE	FREQUENCY OF DETECTION			RANGE OF CONCENTRATIONS		TYPE C(a)	MAXIMUM ABOVE CRITERIA	
METHYLENE CHLORIDE	1	/	5	0.66	-	0.66	5	NO
1,3-DICHLOROBENZENE	1	/	9	0.46	-	0.46	600	NO
1,4-DICHLOROBENZENE	1	/	9	0.19	-	0.19	75	NO
BENZENE	1	/	5	0.25	-	0.25	5	NO
ETHYLBENZENE	1	/	5	1	-	1	700	NO
TOLUENE	1	/	5	0.13	-	0.13	1000	NO
XYLEMES (m-,p-,o-, or total)	1	/	5	0.13	-	0.13	10000	NO
ACENAPHTHENE	1	/	5	14	-	14	3800	NO
DI-N-BUTYL PHTHALATE	1	/	5	0.65	-	0.65	2500	NO
FLUORENE	1	/	5	18	-	18	2500	NO
NAPHTHALENE	1	/	5	3	-	5	750	NO
PHENANTHRENE	1	/	5	28	-	28	75	NO
ARSENIC	1	/	5	53	-	53	50	YES
BARIUM	3	/	5	50.2	-	180	2000	NO
COPPER	3	/	5	4.5	-	7.5	4000	NO
IRON	1	/	1	430	-	430	356	YES
LEAD	2	/	5	1.95	-	2.8	4	NO
MANGANESE	1	/	1	246	-	246	807	NO
NICKEL	2	/	5	1.2	-	3.5	530	NO
SODIUM	1	/	1	21,100	-	21,100	150000	NO
ZINC	4	/	5	1.45	-	11.6	2300	NO

(a) Michigan Department of Natural Resources Operational Memorandum #14, Revision 2, June 6, 1995
All compounds are presented in units of $\mu\text{g/l}$

Table 7-11 Risk Characterization - Site 1
Future Off-Site Ingestion of Groundwater by Residential Users
110th FW, MIANG, Battle Creek, Michigan

ANALYTE	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS	NREPA PA 451 RESIDENTIAL HEALTH-BASED CRITERIA(a)	MAXIMUM ABOVE CRITERIA?
METHYLENE CHLORIDE	1 / 5	0.66 - 0.66	5	NO
1,3-DICHLOROBENZENE	1 / 9	0.46 - 0.46	600	NO
1,4-DICHLOROBENZENE	1 / 9	0.19 - 0.19	75	NO
BENZENE	1 / 5	0.25 - 0.25	5	NO
ETHYLBENZENE	1 / 5	1 - 1	700	NO
TOLUENE	1 / 5	0.13 - 0.13	1000	NO
XYLENES (m-,p-,o-, or total)	1 / 5	0.13 - 0.13	10000	NO
ACENAPHTHENE	1 / 5	14 - 14	1300	NO
DI-N-BUTYL PHTHALATE	1 / 5	0.65 - 0.65	880	NO
FLUORENE	1 / 5	18 - 18	880	NO
NAPHTHALENE	1 / 5	3 - 5	260	NO
PHENANTHRENE	1 / 5	28 - 28	26	YES
ARSENIC	1 / 5	53 - 53	50	YES
BARIUM	3 / 5	50.2 - 180	2000	NO
COPPER	3 / 5	4.5 - 7.5	1400	NO
IRON	1 / 1	430 - 430	356	YES
LEAD	2 / 5	1.95 - 2.8	4	NO
MANGANESE	1 / 1	246 - 246	807	NO
NICKEL	2 / 5	1.2 - 3.5	530	NO
SODIUM	1 / 1	21,100-21,100	150000	NO
ZINC	4 / 5	1.45 - 11.6	2400	NO

(a) Michigan Department of Natural Resources Operational Memorandum #8, Revision 4, June 6, 1995
All compounds presented in units of $\mu\text{g/l}$.

approximately 300 ft from the northwestern edge of Site 1) in concentrations equal to their current concentrations within the Site 1 groundwater.

Evaluation of Contaminated Soil as a Threat to Groundwater

Migration of soil contaminants to groundwater is a future migration pathway which is evaluated under the NREPA PA 451.

There are no chemical-specific industrial cleanup criteria for soils protective of groundwater. To protect future, off-site groundwater users, the groundwater is required to meet residential health-based cleanup criteria at the base boundary. In a worse-case scenario, COPC could leach from the soils, contaminate groundwater and be transported off-site in concentrations which exceed the residential health-based drinking water criteria. Therefore, a conservative evaluation utilizing the residential cleanup criteria to evaluate future impact on groundwater is presented in the following discussions. An evaluation of the potential threat to groundwater is presented in Tables 7-12 for surface soils and 7-13 for subsurface soils. Also included on these tables are:

- The residential 20 times groundwater cleanup criteria; for metals these cleanup values are the higher of the residential 20 times groundwater cleanup criteria or 20 times the background concentration in groundwater
- The background soil concentrations
- The Type A default soil values.

For each chemical of potential concern listed on Tables 7-12 and 7-13, the 95% UCL is listed and compared to the three evaluation criteria. Chemicals detected in the surface soils for which the 95% UCL exceeds the highest of the evaluation criteria include: the metals, antimony, arsenic, beryllium, lead, and zinc, while the 95% UCL for phenanthrene, antimony beryllium, and arsenic were detected in the subsurface soils in concentrations above the evaluation criteria. These results suggest that average on-site soil concentrations are high

**Table 7-12 Evaluation of Surface Soil Values Protective
of Groundwater Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan**

	95% UCL	Residential 20 x Drinking Water	Background	Type A ^(b) default	95% UCL Above Criteria?
ACETONE	8.15	15,000	NA	NA	No
TETRACHLOROETHENE	3.89	100	NA	NA	No
ACENAPHTHENE	264.52	26,000	NA	NA	No
ACENAPHTHYLENE	240.78	520	NA	NA	No
ANTHRACENE	277.69	150,000	NA	NA	No
BENZO(A)ANTHRACENE	630.67	G	NA	NA	No
BENZO(A)PYRENE	603.28	G	NA	NA	No
BENZO(B)FLUORANTHENE	1021.52	G	NA	NA	No
BENZO(G,H,I)PERYLENE	337.73	G	NA	NA	No
BENZO(K)FLUORANTHENE	1179.87	G	NA	NA	No
CHRYSENE	615.59	G	NA	NA	No
DI-N-BUTYL PHTHALATE	186.72	18,000	NA	NA	No
DIBENZO(A,H)ANTHRACENE	237.95	G	NA	NA	No
FLUORANTHENE	844.43	18,000	NA	NA	No
FLUORENE	242.62	18,000	NA	NA	No
INDENO(1,2,3-CD)PYRENE	353.18	G	NA	NA	No
NAPHTHALENE	249.43	5,200	NA	NA	No
PHENANTHRENE	418.15	520	NA	NA	No
PYRENE	729.04	11,000	NA	NA	No
BIS(2-ETHYLHEXYL)PHTHALATE	250.63	G	NA	NA	No
ANTIMONY	0.86	0.120	0.25	--	Yes
ARSENIC	8.78	1	7.14	5.8	Yes
BARIUM	42.06	40	76.43	75	No
BERYLLIUM	0.25	0.08	0.2	--	Yes
CADMUM	0.44	0.10	--	1.2	No
CHROMIUM	16.77	2.0	19.10	18	No
COPPER	11.19	20	7.96	32	No
LEAD	482.56	0.08	16.61	21	Yes
NICKEL	9.26	2	11.43	20	No
SELENIUM	0.43	1	0.59	0.41	No
SILVER	0.38	0.68	--	1.0	No
THALLIUM	0.28	0.04	0.62	--	No
ZINC	50.65	48	29.30	47	Yes

NA - Not Applicable

Organic compounds are presented in units of $\mu\text{g}/\text{kg}$

Inorganic compounds are presented in units of mg/kg

-- Indicates criteria does not exist

G Chemical, due to its physiochemical properties, is not expected to leach through soils to groundwater

ID Inadequate data to develop criteria

(a) Michigan Department of Natural Resources Operational Memorandum #8, Revision 4, June 6, 1995

(b) Michigan Department of Natural Resources Operational Memorandum #5, September 30, 1993

**Table 7-13 Evaluation of Subsurface Soil Values
Protective of Groundwater - Site 1/AOC B
110th FW, MIANG, Battle Creek, Michigan**

	95% UCL	Residential 20 x Drinking Water (a)	Background Soil	Type A default (b)	95% UCL Above Criteria?
SUBSURFACE SOILS					
ACETONE	20.35	15,000	NA	NA	No
ETHYLBENZENE	3.67	1,500	NA	NA	No
XYLEMES (TOTAL)	7.94	5,600	NA	NA	No
DI-N-BUTYL PHTHALATE	759.50	18,000	NA	NA	No
FLUORENE	966.7	18,000	NA	NA	No
NAPHTHALENE	1404.89	5,200	NA	NA	No
PHENANTHRENE	1375.43	520	NA	NA	No
PHENOL	737.22	88,000	NA	NA	Yes
BIS(2-ETHYLHEXYL)PHTHALATE	763.46	G	NA	NA	No
ANTIMONY	1.33	0.12	--	--	Yes
ARSENIC	7.74	1	6.57	5.8	Yes
BARIUM	22.27	40	10.36	75	No
BERYLLIUM	0.14	0.08	0.08	--	Yes
CADMIUM	0.09	0.10	--	1.2	No
CHROMIUM	42.13	2	6.63	18	No
COPPER	7.22	20	4.37	32	No
LEAD	4.74	0.08	3.65	21	No
MERCURY	0.10	0.04	0	0.13	No
NICKEL	17.76	2	6.52	20	No
SELENIUM	0.29	1	--	0.41	No
SILVER	0.11	0.68	--	1.0	No
ZINC	18.49	48	23.45	47	No

Organic compounds are presented in units of $\mu\text{g}/\text{kg}$

Inorganic compounds are presented in units of mg/kg

-- Indicates criteria does not exist

G Chemical, due to its physiochemical properties, is not expected to leach through soils to groundwater

ID Inadequate data to develop criteria

(a) Michigan Department of National Resources Operational Memorandum #8, Revision 4, June 6, 1995

(b) Michigan Department of National Resources Operational Memorandum #15, September 30, 1993

enough to potentially leach from the soils and adversely impact groundwater quality beneath the site.

Some evidence exists suggesting contaminants are migrating into deeper portions of the soil column or from soils to groundwater. Subsurface soil data presented in Sections 5.0 suggest that hydrocarbon concentrations contained within the soils are greatest below approximately 10 bgs. In addition, arsenic was detected in groundwater samples collected from well BC1-MW2 in concentrations which exceed the generic residential and industrial health-based drinking water values. Because arsenic is not a common constituent of heating oil, it is assumed the presence of the heating oil has assisted in mobilizing the arsenic from the soils, and that the arsenic has migrated with the heating oil to the groundwater.

NREPA PA 451 guidance (O.M. #8, Revision 4, June 6, 1995 and O.M. #12, Revision 1, September 9, 1994) states that when the total soil analytical results suggest that leaching of soils contaminants might occur, leachate testing should be completed on these soils. The concentrations of constituents in the leachate are then compared to the applicable groundwater cleanup criteria to determine the final disposition of the soils. Leachate testing was not completed as part of this RI.

7.2.5 Ecological Risk Evaluation

The ground surface at Site 1 / AOC B is grass-covered. The grass is regularly mowed during the spring, summer, and fall. The surrounding on-base property (south, west and east) is asphalt or grass-covered. North of the site, the drainage swale (IRP Site 2) exists between Site 1 and Dickman Road. Because of the lack of sensitive habitat present at or around Site 1 / AOC B, it is unlikely that ecologically sensitive receptors are present at the site.

7.3 BASE BOUNDARY WELLS

The risk characterization for the base boundary wells was completed to estimate the health risk for human receptors. Base boundary wells included in this evaluation are wells BC-MW1

through BC-MW9 and wells BC-MW13, BC-MW14, BC-MW15, and BC-MW16 (Figure 5-14). Section 7.3.1 identifies the chemicals of potential concern in groundwater samples obtained from the base boundary wells. Section 7.3.2 presents an exposure assessment for human receptors, while the risk characterization is presented in Section 7.3.3.

7.3.1 Identification of Chemicals of Potential Concern

Chemicals of potential concern in the groundwater samples collected from the base boundary wells were selected by comparing the chemicals detected in the groundwater to the full list of chemicals regulated under NREPA PA 451. This comparison is presented in Table 7-14. Any chemical detected in the groundwater samples collected from the base boundary wells which is not listed in the NREPA PA 451 cleanup criteria was not retained as a chemical of potential concern.

7.3.2 Exposure Assessment

The purpose of the exposure assessment is to estimate the type and magnitude of human receptor exposure to chemicals of potential concern contained in the groundwater samples collected from the base boundary. The following exposure assessment components are evaluated in this section:

- Characterization of the exposure setting
- Identification of exposure pathways/receptors
- Estimation of chemical concentrations at receptors.

7.3.2.1 Characterization of the Exposure Setting

Groundwater contained in the shallow aquifer beneath the base varies from depths of approximately 9 to 45 ft bgs. Groundwater flow is to the north/northwest under the base at an average hydraulic gradient of 0.004. Wells BC-MW1 through BC-MW9, and BC-MW16 are

**Table 7-14 Selection of Chemicals of Potential Concern Base Boundary Wells
110th FW, MIANG, Battle Creek, Michigan**

ANALYTE	SURFACE SOIL	SUBSURFACE SOIL	GROUNDWATER	REGULATED UNDER NREPA PA 451 (a)
Benzene	NA	NA	X	Yes
Chlorobenzene	NA	NA	X	Yes
Chloroform	NA	NA	X	Yes
1,1-Dichloroethane	NA	NA	X	Yes
1,2-Dichloroethene	NA	NA	X	Yes
1,2-Dichlorobenzene	NA	NA	X	Yes
Ethylbenzene	NA	NA	X	Yes
Methylene chloride	NA	NA	X	Yes
Methyl-tert-butyl-ether	NA	NA	X	Yes
1,1,2,2-Tetrachloroethane	NA	NA	X	Yes
Trans-1,2-Dichloroethene	NA	NA	X	Yes
1,1,1-Trichloroethane	NA	NA	X	Yes
Tetrachloroethene	NA	NA	X	Yes
Trichloroethene	NA	NA	X	Yes
Xylenes (m-,p-,o-, or total)	NA	NA	X	Yes (b)
Benzoic acid	NA	NA	X	Yes
Di-n-butyl phthalate	NA	NA	X	Yes
bis(2-Ethylhexyl)phthalate	NA	NA	X	Yes
Aluminum	NA	NA	X	Yes
Arsenic	NA	NA	X	Yes
Barium	NA	NA	X	Yes
Beryllium	NA	NA	X	Yes
Calcium	NA	NA	X	No
Iron	NA	NA	X	Yes
Lead	NA	NA	X	Yes
Magnesium	NA	NA	X	No
Manganese	NA	NA	X	Yes
Nickel	NA	NA	X	Yes
Potassium	NA	NA	X	No
Sodium	NA	NA	X	Yes
Zinc	NA	NA	X	Yes
Chloride	NA	NA	X	Yes (c)
Sulfate	NA	NA	X	Yes (c)
Dissolved Solids	NA	NA	X	No
Nitrate	NA	NA	X	Yes (c)

(a) Sources - Michigan Department of Natural Resources Operational Memorandum #14, Revision 2 (June 6, 1995) and Operational Memorandum #8, Revision 4 (June 5, 1995)

(b) Considered as total xylenes under NREPA PA 451 guidance

(c) Aesthetic drinking water criteria and exist for these analytes

NA - Not Applicable

constructed as water table wells, while wells BC-MW13, BC-MW14, and BC-MW15 are completed in deeper zones of the surficial aquifer.

The nearest surface water body down-gradient of the western portion of the base is Harts Lake which is located approximately 0.5 miles from the base boundary. The Kalamazoo River, which is located approximately 1.5 miles north of the base, is the nearest surface water body located down-gradient of the main portion of the base.

The base obtains its drinking water from the city of Battle Creek. The nearest, down-gradient, off-site domestic wells lie approximately one mile to the north of the northern base boundary. Two abandoned landfills, identified in the Springfield Wells Site Technical Memorandum (CDM, June 1992) are located between the base boundary wells and these domestic wells.

7.3.2.2 Identification of Exposure Pathways/Receptors

The base is supplied with drinking water by the city of Battle Creek. Therefore, no current on groundwater exposure pathways are complete. Use of this water on-base however, is not prohibited.

The base boundary wells are located along the northern and western edges of the base. Because groundwater flow is directed generally to the north/northwest, these wells are monitoring groundwater quality just before the groundwater moves off-base. Groundwater containing chlorinated VOCs is currently (Figure 5-14), and has been historically (Figure 5-12), present in some of the base boundary wells. Groundwater containing these relatively low concentrations of VOCs, has moved off-base to the adjacent property. There are no current receptors adjacent to the base. The nearest groundwater users are located approximately one mile down-gradient of the base. Current off-site use of the groundwater adjacent to the base boundary is an incomplete pathway and will not be evaluated further. It is unlikely contaminants have migrated one mile past the base boundary and contaminated the nearest down-gradient domestic wells. However, in the future this groundwater may be used as a domestic water supply off-site.

The following exposure pathways and receptors have been evaluated under the future exposure scenario:

- Future ingestion of contaminated groundwater from shallow aquifer production wells (on-site) by base personnel
- Future ingestion of contaminated groundwater from down-gradient shallow aquifer production wells (off-site) by adults and children.

Table 7-15 summarizes the current and future exposure pathways which are considered complete. In addition, Table 7-15 lists the evaluation criteria for each of the complete pathways.

7.3.2.3 Estimation of Chemical Concentrations at Receptors

Ninety-five percent UCLs were not calculated for the groundwater data. MERA 307 guidance (O.M. #8, Revision 3, February 4, 1994) states that the point of exposure for groundwater can be any point in the aquifer, and there is no discussion in the NREPA PA 451 guidance suggesting that this evaluation criteria has changed. The base boundary analytical data will be compared directly to existing chemical-specific cleanup criteria.

7.3.3 Risk Characterization

The risk characterization for the current and future exposure pathways/receptors identified in Section 7.3.2.2 is included in the following subsections.

Future Exposure Pathway - On-site Groundwater Use

Future groundwater use by base personnel was evaluated by comparing the chemicals of potential concern detected in the base boundary groundwater samples to the generic industrial health-based drinking water values. Wells included in the "base boundary wells" are assumed to represent average on-base concentrations of COPC. Generic industrial health-based

**Table 7-15 Current and Future Exposure Pathways - Base Boundary Wells
110th FW, MIANG, Battle Creek, Michigan**

Receptor Population	Exposure Point	Exposure Pathway	Evaluation Criteria
Current Land Use			
Adult and Child	off-site	Ingestion of contaminated groundwater from shallow aquifer production wells	Nearest down-gradient wells ~1 mile from base boundary - not evaluated further
Future Land Use			
Base Personnel	on-site	Future ingestion of contaminated groundwater from shallow aquifer production wells	Generic industrial cleanup criteria
Adult and Child	off-site	Future ingestion of contaminated groundwater from shallow aquifer production wells	Residential cleanup criteria

drinking water values have been developed to protect workers whose drinking water is from an on-site source. The range of chemicals of potential concern in the base boundary wells are presented in Table 7-16 along with the generic health-base drinking water criteria. Because no residential health-based drinking water cleanup criteria exist for chloride, and sulfate, the generic industrial aesthetic drinking water values are listed on this table.

As shown in Table 7-16, bis (2-ethylhexyl) phthalate, and the metals, aluminum, arsenic, iron, lead, and manganese were detected in one or more of the base boundary wells in concentrations exceeding the generic industrial health-based drinking water values. Individual groundwater samples containing one or more of the COPCs in concentrations exceeding the evaluation criteria include BC-MW4 through BC-MW8, BC-MW13, BC-MW14, BC-MW15, and BC-MW16. Based on this evaluation, the groundwater beneath a large portion of the base should be excluded as a potential future source of on-base potable water.

Off-site Groundwater Use

Future groundwater use adjacent to the base by off-site residents was evaluated by comparing the chemicals of potential concern detected in the Site 1 groundwater samples to the NREPA PA 451 generic industrial health-based drinking water values. As stated in the exposure assessment, groundwater containing relatively low concentrations of mainly chlorinated VOCs is migrating off the base and is present beneath the adjacent property. This groundwater could, in the future, be used as a source of domestic water. The residential health-based drinking water cleanup criteria are applicable to the risk evaluation for future off-site groundwater users. The range of chemicals of potential concern in the base boundary groundwater analyses are presented in Table 7-17 along with the residential health-based drinking water criteria. This evaluation excludes well BC-MW16. Because no residential health-based drinking water cleanup criteria exist for chloride, and sulfate, the residential aesthetic drinking water values are listed on this table.

As shown on Table 7-17, bis (2-ethylhexyl) phthalate, and the metals, aluminum, arsenic, iron, lead, and manganese, were detected in one or more of the base boundary wells in concentrations exceeding the residential health-based cleanup criteria.

**Table 7-16 Risk Characterization On-site Ingestion of Groundwater - Base Boundary Wells
110th FW, MIANG, Battle Creek, Michigan**

	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS	INDUSTRIAL CRITERIA (a)	GENERIC INDUSTRIAL CRITERIA	MAXIMUM ABOVE CRITERIA
1,1,1-TRICHLOROETHANE	4 / 15	0.03 - 0.52	200	NO	
1,1,2,2-TETRACHLOROETHANE	1 / 16	0.35 - 0.35	17	NO	
1,1-DICHLOROETHANE	1 / 16	0.19 - 0.19	2,500	NO	
1,2-DICHLOROETHANE	1 / 18	0.28 - 0.28	5	NO	
CHLOROFORM	1 / 12	0.06 - 0.06	100	NO	
METHYLENE CHLORIDE	1 / 17	0.01 - 0.01	5	NO	
TETRACHLOROETHENE	1 / 17	4.6 - 4.6	5	NO	
TRANS-1,2-DICHLOROETHENE	2 / 18	0.04 - 0.15	100	NO	
TRICHLOROETHENE	6 / 18	0.50 - 3.60	5	NO	
1,2-DICHLOROBENZENE	1 / 54	0.03 - 0.03	600	NO	
BENZENE	1 / 18	0.04 - 0.04	5	NO	
CHLOROBENZENE	2 / 36	0.04 - 0.06	100	NO	
ETHYLBENZENE	1 / 18	0.02 - 0.02	700	NO	
METHYL-TERT-BUTYL ETHER	3 / 18	0.08 - 0.22	690	NO	
BENZOIC ACID	3 / 18	2.00 - 4.00	92,000	NO	
DI-N-BUTYL PHTHALATE	1 / 18	1.00 - 1.00	2,500	NO	
BIS(2-ETHYLHEXYL)PHTHALATE	8 / 18	1.00 - 41.00	6	YES	
ALUMINUM	8 / 18	79.9 - 188.00	62.2	YES	
ARSENIC	3 / 18	3.40 - 9.30	50	NO	
BARIUM	13 / 13	22.40 - 89.70	2,000	NO	
COPPER	2 / 18	3.7 - 4.7	4,000	NO	
IRON	11 / 18	45.30 - 2100.00		YES	
LEAD	2 / 18	2.00 - 5.00	4	YES	
MANGANESE	10 / 18	5.7 - 2770.00	807	YES	
NICKEL	1 / 18	48.00 - 48.00	100	NO	
SODIUM	18 / 18	2040.00 - 67100.00	4,500,000	NO	
ZINC	8 / 18	2.5 - 68.50	6,900	NO	
CHLORIDE	17 / 18	0.00 - 159.00	250(b)	NO	
SULFATE	18 / 18	8.19 - 42.9	2,500(b)	NO	
NITRATE	15 / 18	0.4 - 4.0	10	NO	

(a) Type C generic industrial and commercial cleanup criteria (Michigan Department of Natural Resources Operational Memorandum #14, Revision 2, June 5, 1995)

(b) The values presented for chloride and sulfate are the aesthetic drinking water values.

Organic and inorganic compounds are presented in $\mu\text{g/l}$ chloride, sulfate and nitrate are presented in units of mg/l .

**Table 7-17 Risk Characterization Off-site Ingestion of Groundwater - Base Boundary Wells
110th FW, MIANG, Battle Creek, Michigan**

	FREQUENCY OF DETECTION	RANGE OF CONCENTRATIONS			TYPE B (a)	MAXIMUM ABOVE CRITERIA?
1,1,1-TRICHLOROETHANE	4 / 15	0.03	-	0.52	200	NO
1,1,2,2-TETRACHLOROETHANE	1 / 16	0.35	-	0.35	4.3	NO
1,1-DICHLOROETHANE	1 / 16	0.19	-	0.19	880	NO
1,2-DICHLOROETHANE	1 / 18	0.28	-	0.28	5	NO
CHLOROFORM	1 / 12	0.06	-	0.06	100	NO
METHYLENE CHLORIDE	1 / 17	0.01	-	0.01	5	NO
TETRACHLOROETHENE	1 / 17	4.6	-	4.6	57	YES
TRANS-1,2-DICHLOROETHENE	2 / 18	0.04	-	0.15	100	NO
TRICHLOROETHENE	6 / 18	0.50	-	3.60	5	YES
1,2-DICHLOROBENZENE	1 / 54	0.03	-	0.03	600	NO
BENZENE	1 / 18	0.04	-	0.04	5	NO
CHLOROBENZENE	2 / 36	0.04	-	0.06	100	NO
ETHYLBENZENE	1 / 18	0.02	-	0.02	700	NO
METHYL-TERT-BUTYL ETHER	3 / 18	0.08	-	0.22	240	NO
BENZOIC ACID	3 / 18	2.00	-	4.00	32,000	NO
DI-N-BUTYL PHTHALATE	1 / 18	1.00	-	1.00	880	NO
BIS(2-ETHYLHEXYL)PHTHALATE	8 / 18	1.00	-	41.00	6	YES
ALUMINUM	8 / 18	79.9	-	188.00	62.2	YES
ARSENIC	3 / 18	3.40	-	9.30	50	YES
BARIUM	13 / 13	22.40	-	89.70	2,000	NO
COPPER	2 / 18	3.7	-	4.7	1,400	NO
IRON	11 / 18	45.30	-	2100.00	300(b)	YES
LEAD	2 / 18	2.00	-	5.00	4	YES
MANGANESE	10 / 18	5.7	-	2770.00	807	YES
NICKEL	1 / 18	48.00	-	48.00	100	NO
SODIUM	18 / 18	2040.00	-	67100.00	160,000	NO
ZINC	8 / 18	2.5	-	68.50	2,400	NO
CHLORIDE	17 / 18	0.00	-	159.00	250(b)	NO
SULFATE	18 / 18	8.19	-	42.9	250(b)	NO
NITRATE	15 / 18	0.4	-	4.0	10	NO

(a) Type B health-based drinking water values (Michigan Department of Natural Resources Operational Memorandum #8, Revision 4, June 6, 1995).

(b) The values presented for non-chloride and sulfate are the aesthetic drinking water values.

Organic and inorganic compounds are presented in $\mu\text{g/l}$; chloride, sulfate, and nitrate are presented in mg/L.

8.0 SUMMARY AND CONCLUSIONS

This report documents RI activities which EARTH TECH performed at the 110th FW, MIANG, Battle Creek, Michigan under the DOD IRP. The field activities described in this report were conducted between October 31, 1994 and May 17, 1995.

Summaries and conclusions drawn from the investigations concerning background characterization, the base geology and hydrogeology, Site 1/AOC B, Site 3, and the base boundary wells are included in the following subsections.

8.1 BACKGROUND

Representative background concentrations of PP metals plus barium have been established for the surface and subsurface soils and groundwater beneath the base. Development of the soil background concentrations followed guidance contained in the "Verification of Soil Remediation" (MDNR, April 1994, Revision 1).

8.2 BASE GEOLOGY AND HYDROGEOLOGY

The base is underlain by a mantle of Pleistocene-aged glacial drift material, approximately 100 ft thick overlying the Mississippian-aged Marshall Formation. This drift material consists of layers of sand, and sand and gravel, which contain lesser amounts of clay. Thin clay layers and silty or sandy clay layers are present in the deeper sections of the glacial drift material (depths of 65 to 115 ft bgs).

Groundwater in the Battle Creek area occurs in useable quantities in both the glacial deposits and the Marshall Formation. Both aquifers are reported to be unconfined. These two aquifers are reported to be connected hydrologically, although relatively impermeable clay layers may be present locally in sufficient thickness to retard water movement between the glacial materials and the Marshall Formation.

Beneath the base, the depth to the water table in the glacial aquifer ranges from approximately 10 to 40 ft bgs. Three rounds of groundwater elevation measurements obtained from the base monitoring wells each show flow to the north/northwest, although a radial pattern, with a northeastern component of flow, is present in the north-central portion of the base. The May 1994 water table elevation map (Figure 5-2) shows that the base is located hydraulically up-gradient from two abandoned landfills (CDM, June 1992) and from the seven monitoring wells (MW101 through MW107) located on the north side of the landfills. The nearest off-site domestic wells are located approximately one mile north (down-gradient) of the northern base boundary.

8.3 SITE 1: FUEL TANK FARM AND AREA OF CONCERN B: MOTOR POOL DRAINAGE DITCH

Site 1 is located northwest of the Motor Pool parking lot and consists of the former location of four 25,000-gallon ASTs. These ASTs are directly south of the drainage swale (IRP Site 2). AOC B: the Motor Pool Drainage Ditch, borders Site 1 on the east side. The ditch has directed runoff from the Motor Pool to the drainage swale since 1963, and was investigated initially as part of the PA/Site Inspection (EARTH TECH, August 1995).

8.3.1 Geology and Hydrogeology

The glacial drift beneath Site 1 consists primarily of fine- to coarse-grained quartz sand, which contains varying amounts of clay, silt, and/or gravel. A layer of interbedded sand, clayey sand, and gravel underlies the AST area. The groundwater contained in the glacial aquifer beneath Site 1 occurs at an average depth of approximately 25 ft bgs. Groundwater flow beneath the site is to the northwest at an average velocity of 0.67 ft/day.

8.3.2 Analytical Results - Summary and Conclusions

8.3.2.1 Surface Soils

The Site 1/AOC B surface soils contain SVOCs, primarily carcinogenic (i.e., benzo (a) pyrene) and non-carcinogenic PAHs, and metals, particularly arsenic and lead. There are three potential and probable origins for the presence of these compounds in the surface soils:

- Release(s) of fuel from the ASTs
- Coal particles transported from Site 5: Coal Storage Area
- Sandblasting and painting operations completed on or around the ASTs.

Any one or a combination of the three release mechanisms could produce residual hydrocarbon (PAH) concentrations and metals in the surface soils. The analytical results suggest that construction activities completed in the early 1990s (excavation of the pipelines and leveling of the berms) have redistributed the surface soils leaving some areas of Site 1/AOC B (i.e., south of AST 1) relatively free of PAHs and metals.

8.3.2.2 Subsurface Soils

Subsurface soils containing hydrocarbons appear to be limited to an area between former ASTs 2 and 3. Naphthalene and other PAHs are present within the subsurface soils at relatively high concentrations (maximum concentration of 10,000 µg/kg). These hydrocarbons are probably due to the release of heating oil from the former ASTs. The presence of hydrocarbons in the groundwater up-gradient from this location suggests that a separate release occurred along the length of the pre-existing, north-south trending fuel line. No PAHs were detected in subsurface soils collected from locations where this pre-existing fuel line used to be. The absence of hydrocarbons in soils from along the pre-existing fuel line suggests hydrocarbons have migrated through the vadose zone soils to the groundwater. Infiltrating precipitation has likely flushed the fuel from the porous sandy soils beneath the line. This process would explain why the soil samples collected from borings 1SB4, 1SB5,

and BC1-MW2 (advanced along the length of the abandoned fuel line) do not contain residual hydrocarbons.

8.3.2.3 Groundwater

The groundwater analytical results show that an area beneath Site 1 has been impacted by hydrocarbons which have originated from a release of heating oil, or other hydrocarbon-type rich in PAHs. A free-phase layer of hydrocarbons is not present at location BC1-MW2 on top of the groundwater. Groundwater is being monitored at, up-gradient of, and down-gradient (both at the water table and approximately 15 to 20 ft below the water table) of the suspected point of release. Analytical data collected during this RI suggest that the PCE detected in the groundwater screening samples collected as a part of this investigation did not originate from the hydrocarbon (heating oil) release, and that groundwater containing PAHs in excess of the NREPA PA 451 residential health-based drinking water criteria have not migrated past the northern boundary of Site 1.

8.3.3 Risk Characterization

All compounds detected in the Site 1/AOC B soils and Site 1 groundwater samples which are considered under the NREPA PA 451 were selected as chemicals of potential concern.

Exposure scenarios evaluated for Site 1/AOC B include the present use of the land by base personnel and the future use of the land (construction activities) and groundwater by base personnel and off-site residents. Per requirements under NREPA PA 451, the potential threat that contaminated soils pose to the groundwater was also evaluated as part of the future groundwater use scenarios. The most reasonably exposed populations include the current and future base personnel, future excavation workers, and off-site adults and children.

Complete current pathways include the direct contact (ingestion and dermal absorption) by base maintenance and ANG personnel to contaminated soil. Complete future pathways include ingestion of contaminated groundwater by base personnel and off-site residents and

the direct contact to soils and inhalation of particulates generated by construction activities by excavation workers.

A site-specific risk assessment was developed only for the future excavation worker exposure scenarios. Guidance developed by the MDNR under the NREPA PA 451 for residential and generic industrial exposure scenarios were applied to the direct contact to contaminated soils, and future on- and off-site groundwater ingestion exposure scenarios.

The results for current soil exposures show the reasonable maximum concentrations of chemicals of potential concern in the subsurface soils do not exceed the generic industrial direct contact criteria. The reasonable maximum concentration of lead in the surface soils exceeds the generic industrial direct contact criteria for lead, suggesting the current exposure to base personnel from lead in the surface soils should be mitigated. If exposure to the surface soils encompassing location 1SB12 could be mitigated, the 95% UCL lead concentration remaining in the surface soils would be below the generic industrial cleanup criteria for lead (400 mg/kg).

In the future, an unacceptable risk may be present to Site 1/AOC B construction workers through inhalation of arsenic-containing dust.

Future on-site use of the groundwater contained within the surficial aquifer beneath Site 1 should be prohibited based on the occurrence of arsenic and iron in concentrations above the generic industrial health-based drinking water criteria. Groundwater existing within the surficial aquifer beneath Site 1 will eventually flow off-base. A worst-case evaluation of future off-site risks from groundwater ingestion was completed by comparing concentrations of chemicals of potential concern in the Site 1 groundwater samples to the NREPA PA 451 health-based drinking water values. Phenanthrene, arsenic, and iron were detected in concentrations exceeding the residential health-based drinking water values. Future off-site risks due to the presence of chemicals of potential concern in the groundwater samples were not evaluated by fate and transport modeling. This evaluation assumes future off-site groundwater concentrations will equal the current groundwater concentrations. However, it is anticipated that as the groundwater moves towards the base boundary, contaminant

concentrations will decrease due to the combined effects of dispersion, diffusion, and biodegradation.

Using guidelines developed under NREPA PA 451 it was determined that antimony, arsenic, beryllium, lead, and zinc in surface soils and phenanthrene, antimony, arsenic, and beryllium in the subsurface soils could be released or leached from the soils and adversely affect groundwater quality beneath the site. Leachate testing was not completed during this RI. However, testing completed during development of the Site 5 Action Memorandum showed arsenic at a concentration of 20 mg/kg is not leachable from the soils in concentrations which are great enough to adversely effect groundwater quality (EARTH TECH, September 1995).

8.3.4 Environmental Assessment

The ground surface at Site 1/AOC B is grass-covered. The grass is regularly mowed during the spring, summer, and fall. The surrounding on-base property (south, west and east) is asphalt or grass-covered. North of the site, the drainage swale (IRP Site 2) exists between Site 1 and Dickman Road. Because of the lack of sensitive habitat present at or around Site 1/ AOC B, it is unlikely that ecologically sensitive receptors are present at the site.

8.4 SITE 3: FIRE TRAINING AREA

Site 3 is located on the western part of the base, southwest of the civil engineering storage yard. Fire training exercises were completed at this site from approximately 1977 to 1986 and used approximately 54,000- to 74,000- gallons of a mixture of waste JP-4, oils, hydraulic fluid, and spent cleaning solvents.

8.4.1 Summary and Conclusions - Soils

Site 3 surface and subsurface soil samples collected from inside the bermed area during this RI were only analyzed for PP metals plus barium. The metals barium, cadmium, chromium, lead, and zinc were detected in the surface soil samples in concentrations exceeding their

respective background concentrations. These metals were also detected in the 5 to 7 ft bgs intervals, but in concentrations below respective background concentrations.

8.4.2 Summary and Conclusions - Groundwater

Benzene was detected in the Site 3 groundwater samples above its respective residential health-based drinking value, while antimony was detected in the groundwater samples above background concentrations.

8.5 BASE BOUNDARY WELLS

The base boundary wells were installed in 1988 in response to concerns that the base was contributing to groundwater contamination of the drinking water wells north of Dickman Road.

An evaluation of the January 1992 (CDM, June, 1992) and May 1994 groundwater analytical data suggests that there is leachate being generated by a source of groundwater contamination located north of the northern base boundary. This source contains metals (sodium and arsenic) in relatively high concentrations. The presence of arsenic and sodium in the base boundary wells could be attributed to the diffusion or dispersion of leachate generated from a source of groundwater contamination located north of the base boundary wells to the base boundary wells.

Although some of the metal detections found in the base boundary wells may have originated from a source of contamination located north of the northern base boundary, the historic detection of chlorinated solvents, for example TCE and PCE, in groundwater samples collected from wells BC-MW4, BC-MW5, BC-MW6, and BC-MW16 suggest that contaminants have migrated from an unidentified up-gradient location and are affecting groundwater quality beneath the base. This location may be either on-base south/southeast (up-gradient) of BC-MW16, or off-base south/southeast of BC-MW16. The trend of chlorinated VOC concentrations in groundwater samples collected from well BC-MW4, for example, shows that relatively low concentrations of TCE have been detected in successive sampling events. TCE

concentrations of 3.2, 4.0, 2.1, and 2.1 $\mu\text{g/l}$ were quantified in samples from BC-MW4 during 1989, 1991, May 1994, and December 1994 sampling events, respectively. These data suggest the TCE concentrations are decreasing slightly. A similar trend in TCE concentrations is evidenced from three rounds of sampling (1989, 1991, and May 1994) completed from well BC-MW5. Although some evidence exists suggesting chlorinated solvent concentrations increase up-gradient from base boundary well BC-BW4, no VOCs were detected in groundwater samples collected from the base boundary wells in concentrations exceeding NREPA PA 451 residential health-based drinking water values.

Regardless of the location of the suspected up-gradient source of contamination, the existing network of monitoring wells and the May/December 1994 groundwater analytical data obtained from these wells shows that organic compounds (except for bis (2-ethylhexyl) phthalate, a common laboratory contaminant) are not present in the base boundary wells in concentrations exceeding the NREPA PA 451 residential health-based drinking water values. Additionally, all historic data (1989, 1991, and 1994) show that, in general, chlorinated VOC concentrations obtained from groundwater samples collected for the base boundary wells are decreasing.

The metals aluminum, iron, lead and manganese were detected in one or more of the groundwater samples obtained from the base boundary wells in concentrations exceeding background or the residential health based drinking water values. However, as shown on Figure 5-14, each of these metals were detected above the residential health-based drinking water values in at least one groundwater sample used to calculate the groundwater background (wells BC-MW9, BC-MW11, and BC-MW12). These data suggest the occurrences of these metals are related to variations in the natural groundwater chemistry beneath the site.

9.0 RECOMMENDATIONS

Recommendations for Site 1, Site 3, and the base boundary wells are presented in the following subsections.

9.1 SITE 1 RECOMMENDATIONS

The following specific recommendations are presented for Site 1/AOC B:

- Prepare a FS which evaluates surface soils around AST 1 (soil boring location 1SB12) and evaluates the future impact contaminated surface and subsurface soils may have upon the Site 1 groundwater.
- Prohibit base personnel from using the Site 1 groundwater as a future source of potable water.
- Periodically monitor Site 1 groundwater concentrations for SVOCs and metals to evaluate if contaminants are being transported off-site in concentrations above NREPA PA 451 residential health-based drinking water values; include the base boundary wells BC-MW6 and BC-MW14, located approximately 300 ft down-gradient of Site 1, in the future monitoring program.

9.2 SITE 3 RECOMMENDATIONS

The nature and extent of metals in the surface and near surface soils at Site 3 should be determined. This assessment may be included in the Site 3 activities being completed by the AFCEE, which is addressing groundwater contamination under a natural attenuation study.

9.3 RECOMMENDATIONS

Specific recommendations for the base boundary wells are included in the following:

- Prohibit base personnel from using the base groundwater as a source of potable water; aluminum, iron, lead, and manganese concentrations may be elevated locally or regionally above NREPA PA 451 residential aesthetic health-based drinking water values.
- No further remedial action is recommended to characterize groundwater quality base-wide or along the base boundary. This recommendation is based on the May/December 1994 groundwater analytical results which show chlorinated solvent concentrations below NREPA PA 451 residential health-based drinking water values and the trends in the groundwater analytical data. These trends show that in general, concentrations of chlorinated VOCs are decreasing in the groundwater samples obtained from the wells along the northern base boundary.

10.0 BIBLIOGRAPHY

Air Force Center for Environmental Excellence, *Completion of One-Year Bioventing Test, IRP Site 3, 110th FW, MIANG*, May 17, 1994.

Camp Dresser and McKee, *Springfield Wells Site Final Technical Memorandum*, June 1992.

Earth Technology Corporation, *Final Source Removal Action Plan, Site 5 - Coal Storage Area, 110th FW, Michigan ANG, W. K. Kellogg Airport, Battle Creek, Michigan*, June 1994.

Earth Technology Corporation, *Draft Final RI Work Plan, 110th FW, MIANG, Battle Creek, Michigan*, September 1994.

EARTH TECH, *Final Preliminary Assessment/Site Inspection Report, 110th FW, Michigan ANG, W. K. Kellogg Airport, Battle Creek, Michigan*, April, 1996.

Engineering - Science, *IRP Draft Immediate Response Report, 110th TASG, Michigan ANG, 1988.*

Engineering - Science, *Part 1 Bioventing Pilot Test Work Plan and Part II Draft Interim Pilot Test Results for IRP Site 3, Battle Creek ANG, Michigan*, November 1992.

Engineering - Science, *Final Site Investigation Report, 110th TASG, Michigan Air National Guard, W. K. Kellogg Regional Airport, Battle Creek, Michigan*, November 1993.

Engineering - Science, *Draft Final Source Removal Action Plan, Site 2 - Drainage Swale, 110th Fighter Group, Michigan Air National Guard, W. K. Kellogg Airport, Battle Creek, Michigan*, June 1994.

Freeze, R. A. and Cherry, J. A., *Groundwater*, Prentice Hall, Inc., 1979.

Grannemann and Twenter, *Geohydrology and Groundwater Flow at Verona Well Field, Battle Creek, Michigan*. U.S.G.S. Water Resources Investigations Report 85-4056.

Hazardous Materials Technical Center (Dynamic Corporation) "Installation Restoration Program Phase 1 Records Search: 110th TASG, Michigan Air National Guard, W. K. Kellogg Regional Airport, Battle Creek, Michigan, June 1987.

Hickok and Associates, *Base Environmental Assessment*. 110th Fighter Group, Michigan Air National Guard, 1985.

Martin Marietta Energy Systems (HAZWRAP), *Requirements for Quality Control of Analytical Data*, DOE/HWP-65/R1; Oak Ridge Gaseous Diffusion Plant, Analytical Chemistry Department; July, 1990

Personnel Communication, 110th Fighter Group Environmental Coordinator to EARTH TECH, January 1995

Radian Corporation, *Management Action Plan*, 110th FW, MIANG, Battle Creek, Michigan, July 1994.

State of Michigan, MDNR; *Operational Memorandum #15*, September 30, 1993.

State of Michigan, MDNR; *Operational Memorandum #12*, Revision 1, September 1994.

State of Michigan, MDNR; *Thomas Weise Personal Communication*, November 28, 1994.

State of Michigan, MDNR, *Operational Memorandum #8*, Revision 4, June 5, 1995.

State of Michigan, MDNR, *Operational Memorandum #14*, Revision 2, June 6, 1995.

United States Department of Agriculture, *Soil Conservation Service, Soil Survey of Calhoun County, Michigan*, in press

United States Environmental Protection Agency, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, December 1989.

Vanlier, Kenneth E., 1966. *Groundwater Resources of the Battle Creek Area, Michigan.*
Michigan Geological Survey, Water Investigation 4.